

**BBC** JAMES LOVELOCK ON THE COMING AGE OF HYPERINTELLIGENCE

# Science Focus

To infinity and beyond

*The tech that*  
**SNIFFS OUT DISEASE**

*Why fizzy drinks and*  
**FISH FINGERS WON'T KILL YOU**

*Is too much*  
**SUN CREAM BAD FOR YOU?**

## SPACE 2069

**MOONBASES, MARS,  
FIRST CONTACT, AND BEYOND...**



**APOLLO  
SPECIAL  
ISSUE**

**Moon Landing**

How to argue with someone  
who thinks it was fake

**Small Steps**

How NASA prepared  
for the first moonwalk

**The Missions**

50 years of lunar  
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CAPTURE TOMORROW





# FROM THE EDITOR



Fifty years ago, on 20 July 1969, humans first set foot on the Moon. It was a moment that captured the world's imagination like no other, inspiring a generation of scientists, engineers and artists alike. Sadly, a few years later, as priorities – and, of course, money – shifted away from the Moon, Gene Cernan would unwittingly become the last person to walk across the lunar surface in 1972, and one of the last people to leave a low-Earth orbit.

In the time since, our exploration of space, particularly in the last decade, has exploded. Okay, so we might not have put our feet on other worlds, but in the last 10 years we've visited the outer limits of our Solar System, observed Earth-like planets orbiting distant stars, landed on an asteroid hurtling through space, looked back at the beginning of space and time itself and, most recently, captured an image of a black hole 55 million light-years away using a telescope the size of our planet. It's dizzying to think about what might come next. So we've left that vertigo-inducing task in the capable hands of award-winning sci-fi author Stephen Baxter on p44. And, if you know anyone out there who's convinced the Moon landing was faked, turn to p64 and find all the ammo you need to prove them wrong.

*Daniel Bennett*

Daniel Bennett, Editor

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## ON THE BBC THIS MONTH...

### Television

*The Sky At Night Special: The Moon, The Mission And The BBC*  
The world's longest-running science TV programme celebrates the 50th anniversary. Guests include Helen Sharman, Britain's first astronaut. Check *Radio Times* for details.

### Television

*Stargazing: Moon Landing Special*  
Brian Cox will be joined by Dara O Briain, Hannah Fry and Kevin Fong, in this 90-minute special episode. Check *Radio Times* for details.

### Television

*8 Days: To The Moon & Back*  
Don't miss this unique retelling of the Apollo 11 mission. *8 Days* uses digital effects and dramatised performances to bring hours of declassified audio from the missions to life. Check *Radio Times* for details.

How hot would a pavement have to be to fry an egg on it? → p81

## CONTRIBUTORS



### AMY SHIRA TEITEL

How do you practise walking on the Moon? Spaceflight historian Amy looks at the training methods that put Apollo astronauts through their paces. → p36



### JAMES LOVELOCK

On the eve of his 100th birthday, the man who first proposed the Gaia hypothesis shares his new theory with us. → p56



### DAVID SPIEGELHALTER

If you believe the papers, sugary treats and processed food are going to kill you. Well it's not quite as simple as that. David helps us navigate the headlines. → p32



### ROSIE MALLET

'E-noses' – electronic devices that can sniff out disease – could soon be helping us pick up signs of illnesses, years before they can be detected by current methods. Rosie tells us more. → p73

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“I think it’s sheer hubris to think about your sense of meaning. Life is something to be enjoyed”

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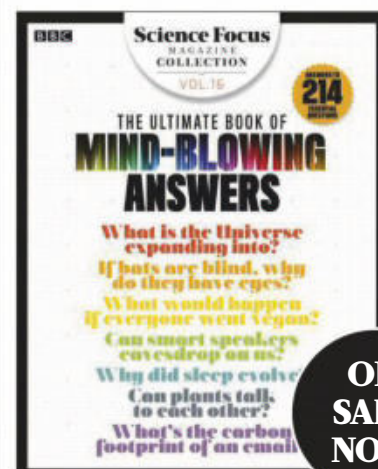
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## SPECIAL ISSUE



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## EYE OPENER

# Putting the art in AI

OXFORDSHIRE, UK

Meet a pioneer of the art world: Ai-Da. She's the first robot artist able to draw from sight. The brainchild of Oxford gallery director Aidan Meller, Ai-Da's body was created by Cornish robotics firm, Engineered Arts. Her head is made lifelike with silicone skin, 3D-printed teeth and gums, and individually punched hair.

The secret to Ai-Da's artistic prowess lies in AI algorithms, developed at the University of Leeds, that process the information captured by her camera eyes and send instructions to her mechanical arm. Ai-Da can sketch people in pen and pencil, and also creates abstract artworks such as those shown here. For these, her artistic output is passed through further algorithms, printed on canvas and painted over by a human. Ai-Da's first London show is scheduled for later this year.

SHUTTERSTOCK

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# CONVERSATION

YOUR OPINIONS ON SCIENCE, TECHNOLOGY AND BBC SCIENCE FOCUS

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## LETTER OF THE MONTH

### Chasing sunlight

I regret that your answer to the question on flying round the world in daylight is incorrect (May, p83). Yes – if you left at noon and arrived at noon. However, if you took off at dawn and arrived at sunset then you have 36 hours to make the trip and would only need to average the speed of sound. Since you say it has been completed in 33 hours, it is more than theoretically possible.

**David Glover**

You're right, it is theoretically possible. The time needed to make the circumnavigation in daylight depends on both the time of take-off and the plane's speed relative to the

Sun. A conventional airliner would need at least 44 hours to circumnavigate the equator, while the Sun takes just 24 hours. So the plane would need at least a 20-hour headstart to complete the trip before darkness overtakes it. But at the equator the biggest headstart available – the time between sunrise and sunset – is just 12 hours. Concorde could theoretically have done it, with its record circumnavigation time of around 31.5 hours in 1995 (not 33 hours as stated originally). It thus needed just a 7.5-hour headstart, but sadly for practical reasons the plane never actually flew around the equator.

**Robert Matthews**, BBC Science Focus science consultant



### WRITE IN AND WIN!

The writer of next issue's *Letter Of The Month* wins **Plantronics Backbeat Go 810 wireless headphones**.

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### Power problems

With regard to your article on Chernobyl (July, p36), there is a certain irony. I read a recent article, in *The Telegraph* business supplement, suggesting that the Russian Nuclear Energy Agency – Rosatom – was doing well, setting up reactors in a variety of Third World states. It is only in the West that the difficulties occur; as illustrated by the German decision to ban nuclear power following Fukushima, even though the chances of a Tsunami striking Germany seem decidedly low. In fact, there seems to be a considerable degree of irrationality and ignorance when it comes to

We shouldn't be afraid of nuclear power, says Peter Davey

nuclear power – you will probably have seen the badge featuring the Sun with a smiling face and the words 'Nuclear Power – No Thanks!' underneath. The wearers are apparently unable to grasp that





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**“WE KNOW MORE ABOUT THE SURFACE OF MARS THAN WE DO ABOUT THE BOTTOM OF THE OCEAN... IT'S MUCH MORE IMPORTANT TO KNOW ABOUT OUR OCEAN”**

JAMES LOVELOCK, p56

the Sun represents the largest nuclear reaction in the Solar System, by an enormous factor. Actually it is an explosion. Only the Sun's immense gravity stops it from expanding outwards and overwhelming the inner Solar System, which is a situation that will not last forever.

Peter Davey, via email

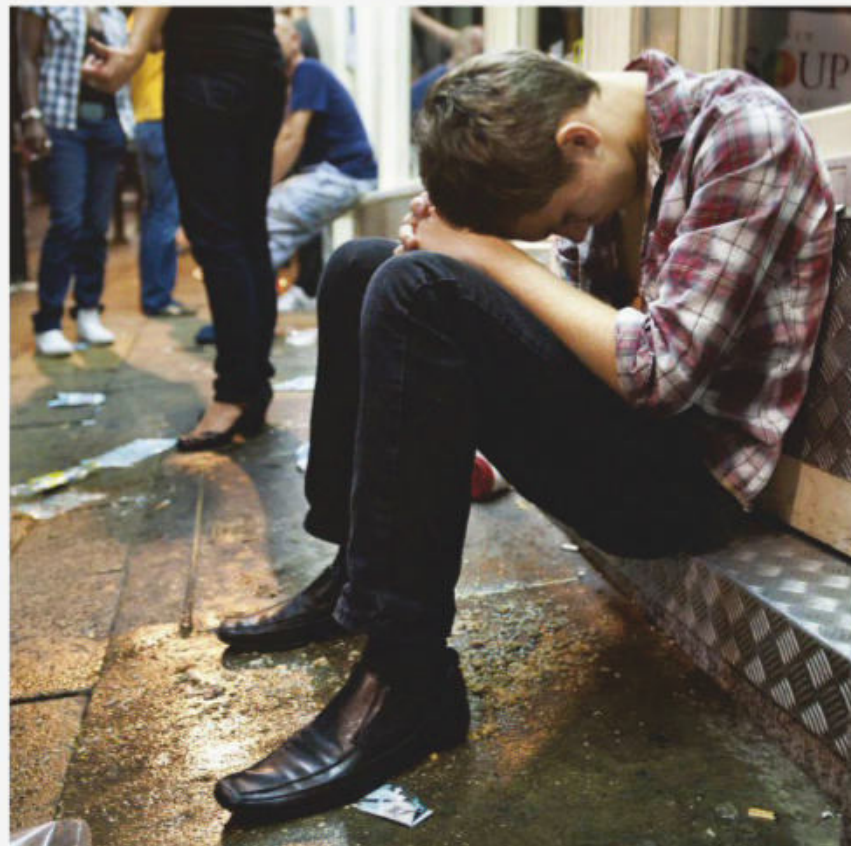
## Making a man

Your interview with Dr Gary Barker in the July (327) issue that talked about the idea of harmful masculinity was an interesting read, but Barker's ideas on on how to make meaningful change left me cold. The best solution I've seen was actually presented in a BBC show called *No More Boys and Girls*. The programme posed questions on whether schools could educate children free from gender stereotypes. It was remarkable to see how, at such an early age, the young boys thought being a man meant being tough and strong. And importantly, when it came to their problems, silent. In just a short time, the class made a significant change to these boys' and girls' lives. If we're to make a difference we need to start young.

Phil Barnet, via email

## Bring on the booze

Something occurred to me when I read your piece on



If hangover-free alcohol was available, would we behave irresponsibly?

synthetic alcohol (Alcarelle) in the May issue. If it does indeed prove to be safe to consume, and they can make it appealing to drink, is consequence-free alcohol something we really need in the world? A hangover is really only a consequence if you drink *too much*. Without the threat of the ill effects, might

**“A HANGOVER IS ONE OF THE DETERRENTS WE NEED TO LIMIT THE NUMBERS OF DRUNK PEOPLE”**

people be tempted to binge drink more than they already do? One of the reasons we see people binge drink on the weekend and not in the week is that they need to be to turn up to work the next day. With A&E visits at the weekend as a result of binge drinking, could we see a sharp rise in antisocial behaviour in the week if Alcarelle became widely available?

Surely the threat of a hangover is one of the deterrents we need to limit the numbers of drunk and disorderly. You only have to walk through Bristol's Harbourside on a Friday night, to know that you wouldn't want that scene to be repeated every night of the week!

Sue Jones, Bristol





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## PEAS IN A POD

Dolphins prefer friends with similar interests **p15**

## PARENTS REJOICE

Artificial intelligence deciphers baby screams **p16**

## THINK OR SWIM

Seals actively control their circulation pre-dive **p20**

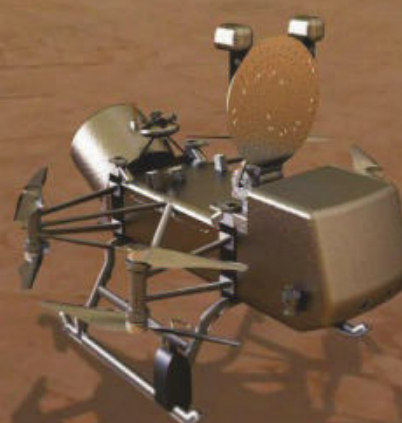
## A NEW DAWN

The first long range solar-powered car **p21**

# DISCOVERIES

## NASA TO SEND A DRONE TO EXPLORE SATURN'S BIGGEST MOON

Project Dragonfly is scheduled for launch in 2026



NASA has announced an ambitious new mission to look for evidence of past and even present life on Saturn's largest moon, Titan. The Dragonfly mission will consist of a high-tech drone that NASA calls a rotorcraft. Powered by a nuclear generator, it will land in the 'Shangri-La' dune-fields near Titan's equator. From there, it will use its eight rotors to fly to dozens of sites across the moon, taking samples and performing analysis.

Titan's chemical composition is thought to resemble that found on the primordial Earth. In studying the moon, scientists hope that Dragonfly will be investigating the ➤

Concept of Dragonfly entry, descent, landing, surface operations and flight on Titan

NASA

**Stressed sheepdogs** Feeling the strain? So is your dog **p14** **Truth about vaping** Are e-cigs dangerous? **p22**  
**Wellcome Photography Prize** Intriguing shots from the world of science **p24**



# News in brief

## IS JUNK FOOD BEHIND FOOD ALLERGY INCREASE?

Food allergies are on the rise – especially in kids – and now we may know why. Researchers have found a link between junk food and food allergies in kids aged 6 to 12. The study, at the University of Naples Federico II, found higher levels of ‘advanced glycation end-products’ (AGEs) in children with food allergies. AGEs are

formed when proteins or fats combine with sugars, and large amounts are present in highly processed foods. “Existing hypotheses of food allergy do not adequately explain the dramatic increase [of allergies] observed in the last years,” said study leader Dr Roberto Berni Canani. “Dietary AGEs may be the missing link.”



• chemical environment that gives rise to life on Earth. It will also look for evidence of life on Titan.

“Visiting this mysterious ocean world could revolutionise what we know about life in the Universe,” said NASA administrator Jim Bridenstine in his announcement of the mission on 27 June 2019.

Dragonfly will be the first drone to fly on another planet. As the operators gain experience flying the craft, they will build up to a series of longer flights, called leapfrogs. Each of these will take the rotorcraft up to eight kilometres at a time. The goal is to reach the Selk impact crater, where there is evidence for liquid water and carbon-rich molecules having once existed in abundance. These are the conditions that scientists think are essential for life to emerge.

Titan has been visited once before by the European Space Agency’s Huygens lander. It was carried to the Saturnian system by NASA’s Cassini spacecraft, which completed a 13-year tour of Saturn and its moons in September 2017. Among other things, Cassini revealed that Titan had lakes of liquid methane across its surface.

“[Dragonfly] is a really exciting mission that follows on from the findings of the Cassini mission. Titan is like a primordial Earth, covered in liquid methane lakes. If we were to find life outside of Earth but within our Solar System, places like Titan would be prime candidates,” said Dr Sheila Kanani of the Royal Astronomical Society in London.

NASA hopes to launch Dragonfly in 2026. It will arrive at Titan in 2034, and its mission is planned to last for at least 2.7 years.

by **STUART CLARK**  
*Stuart is an astronomy journalist.*

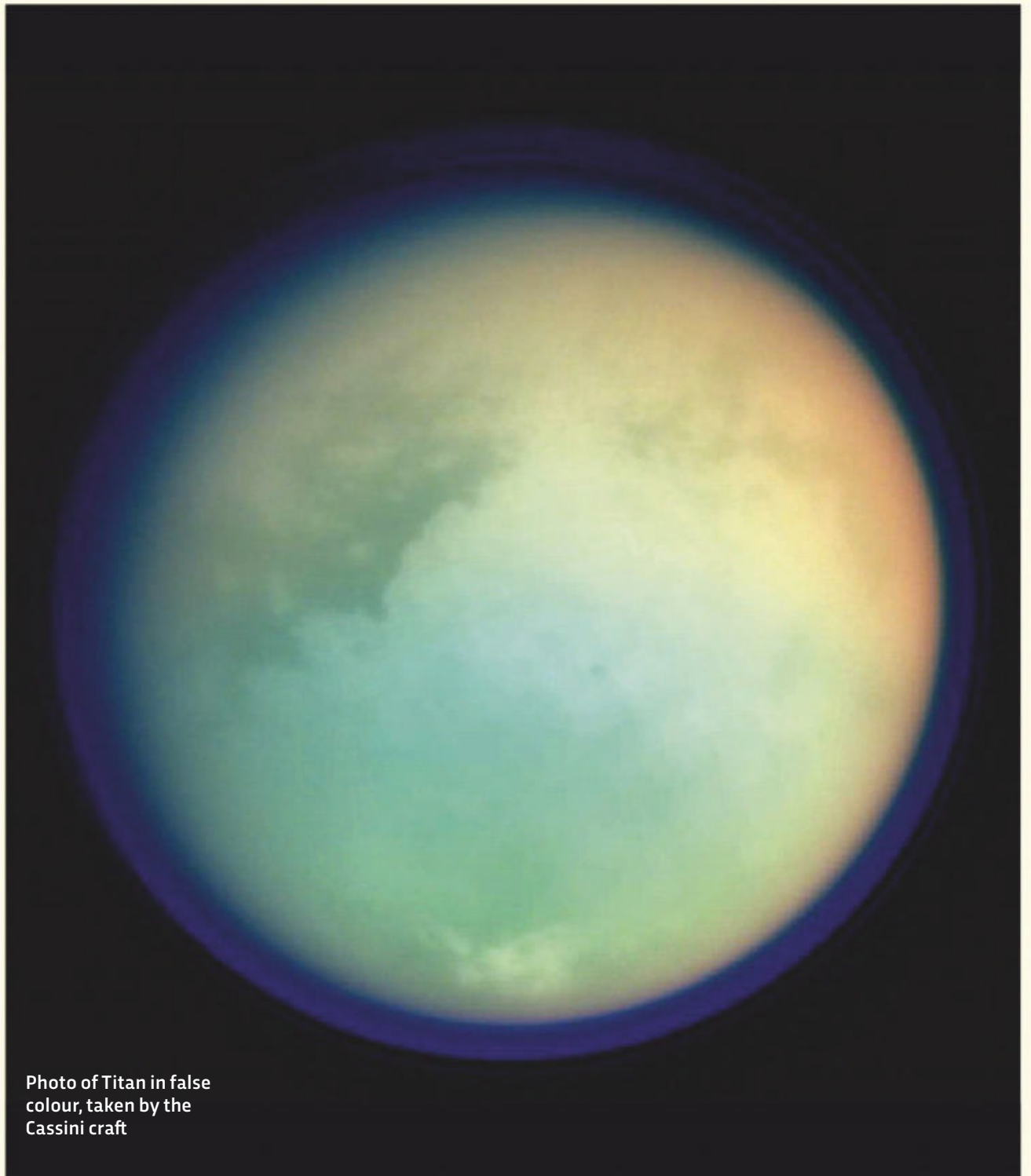


Photo of Titan in false colour, taken by the Cassini craft



**TITAN  
IN NUMBERS**

**x4**

Titan is the only moon in the Solar System with an appreciable atmosphere. It is four times denser than Earth’s atmosphere.

**15 DAYS  
22 HOURS**

This is the amount of time it takes Titan to orbit Saturn. Titan keeps its same face to Saturn, like our Moon does to Earth.

**-179°C**

This is the surface temperature on Titan. This means that methane can exist as a liquid, and water freezes as hard as rock.

**90%**

The amount of sunlight falling on Titan that is absorbed by its thick atmosphere. This means that it is always twilight.

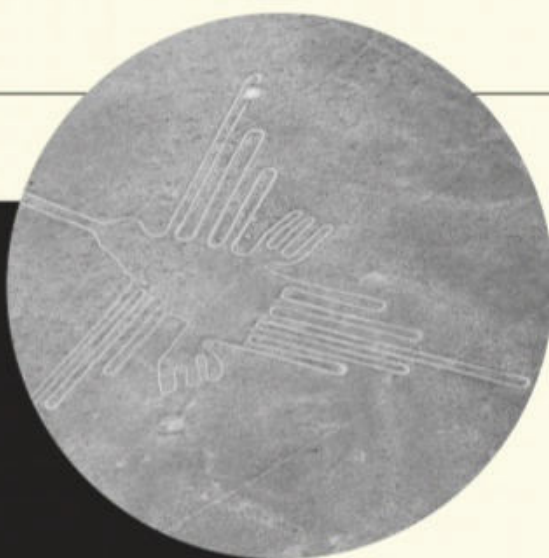
**25 MARCH  
1655**

The date that Titan was discovered by the Dutch astronomer Christiaan Huygens, after whom the ESA lander was named.



### EXOTIC MIGRATORY BIRDS IDENTIFIED IN PERU'S MYSTERIOUS NAZCA LINES

The lines of Nazca and Palpa were carved into the ground over 1,000 years ago, and what they represent is a mystery. But now, a study of more than 2,000 of the carvings has identified a hermit thrush, a guano bird and a pelican – none of which are native to the area.



## They did what?

### Salmon put on a treadmill

#### WHAT DID THEY DO?

A team at the University of British Columbia placed Atlantic salmon in swim tunnels with adjustable water flows – essentially a fish treadmill – and tested their endurance capabilities.

#### WHY DID THEY DO THAT?

They wanted to test the effect of plasma-accessible carbonic anhydrase (paCA). This is an enzyme anchored to the walls of the blood vessels of salmon and is thought to play an important role in their cardiovascular function. They inhibited the paCA in some fish and tested their ability to swim against strong water.

#### WHAT DID THEY FIND?

They found that the paCA enzyme kicks in when the fish were in low oxygen environments. It helps to reduce how hard the hearts of the salmon had to work by up to 27 per cent. "It appears paCA plays a key role in enhancing the animal's ability to extract oxygen from their blood, making salmon great aerobic athletes and giving them a much-needed edge during migration," said study leader Till Harter. They now plan to test for the effect in other types of salmon and other bony fish.



Staying up late is bad for your health, but it's easy to change your routine

## HUMANS

# Night owls can become larks in just three weeks

Night owls – people who prefer to go to bed and wake up late – could change their body clocks to boost their performance, eating habits and mood. Night owls are at a disadvantage in modern life because working days cater towards morning larks, with their earlier sleep/wake cycles. This leaves night owls suffering from lack of sleep, daytime drowsiness and poorer mental wellbeing.

A team of researchers from the UK and Australia carried out a small study to see if night owls could make tweaks to their routine to bring forward their sleep and wake times, without impacting their total snoozing duration. Over the course of three weeks, 22 participants – who had an average bedtime of 2:30am and an average waking time of 10:15am – went to bed two to three hours earlier every day, and set their alarms for two to three hours before their normal waking time. They were asked to eat breakfast as soon

as possible after getting up, and to get lots of sunshine in the morning, while reducing daylight exposure in the evening. They also had their dinner no later than 7pm.

At the end of the study, reaction times and grip strength in the participants had improved in the morning, suggesting better mental and physical performance. Breakfast was eaten more frequently and participants reported improvements in mood, a reduction in stress and less daytime sleepiness.

"Establishing simple routines could help 'night owls' adjust their body clocks and improve their overall physical and mental health," said Prof Debra Skene from the University of Surrey, who was involved in the research. "Insufficient levels of sleep and circadian misalignment can disrupt many bodily processes putting us at increased risk of cardiovascular disease, cancer and diabetes."



### DOGS' STRESS LEVELS MIRROR THEIR OWNERS

If your screaming kids, nagging boss and mounting debts are driving you mad, the chances are your pooch is feeling the burn too. Dogs mirror the stress levels of their owners, according to a study at Linköping University, Sweden. The team monitored the levels of the stress hormone cortisol in

25 border collies, 33 Shetland sheepdogs and their owners over several months. "We found that the levels of long-term cortisol in the dog and its owner were synchronised, such that owners with high cortisol levels have dogs with high cortisol levels, while owners with low cortisol levels have dogs with low levels," said Ann-Sofie Sundma, who led the research.



# Trending

YOUR GUIDE TO WHO'S SAYING  
WHAT ABOUT THE HOTTEST TOPICS  
IN THE WORLD RIGHT NOW



### #Male contraceptive

James Owers and Diana Bardsley, a couple from Edinburgh, have become among the first people in the world to trial a male contraceptive gel. The gel is rubbed onto the chest and switches off sperm production in the testes.

#### Gene Matthews

@GeneMatthewsLaw

Interesting clinical trial for male contraceptive gel started in the new year. If successful, it should provide a further reliable contraceptive option for men (perhaps better sharing the responsibility).

B

@bacloughton

Injectations... Implants... Hormonal pills...copper coils... Vs Gel I'm extremely JEALOUS AND ANNOYED

### #Heatwave

Summer heatwaves have been sweeping across Europe. According to a climatology institute in Potsdam, Germany, Europe's five hottest summers since 1500 have all been in the 21st Century.

#### Simon King

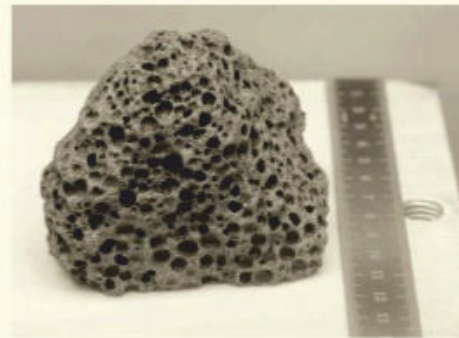
@SimonOKing

New June records were broken in Germany, Poland and the Czech Republic yesterday. Heat eases off here today but it intensifies in Spain and France, with the French June record (41.5°C) likely to be beaten, definitely by tomorrow when all-time record is under threat. #heatwave

#### BBC Springwatch

@BBCSpringwatch

It's certainly warm out! As this heatwave continues, leave out extra drinking water for our garden visitors and extra dog or cat food [for hedgehogs] as worms dig further into the ground! And fill up an old washing up bowl for a bird bath!



### #Moon rock

For the first time in decades NASA has decided to study some pristine Moon rocks collected by Apollo astronauts nearly 50 years ago.

#### snopes.com

@snopes

This may complicate some conspiracy theories...

#### The Science Coalition

@scicoalition

@NASA will allow Moon rock samples – taken during the Apollo Moon landing 50 years ago – to be studied by geologists using 21st-Century technology. What will they find with our modern tech? #ThankstoScience #Apollo50

#### Irene Sans

@IreneSans

I need a rock like this!

KEEP IN TOUCH



@SCIENCEFOCUS

### #Baldness

Researchers in California have developed a treatment to reverse baldness using stem cells. The team hopes to start human trials soon.

#### Alma Reising

@ReisingAlma

To all balding older (or younger) men out there or victims of inheriting male pattern baldness from their mum's fathers, like my sons: @LBC @lbcbreaking just announced that a cure may have been found!! Whoohoo #hair #MenToo

#### Tony Dewhurst

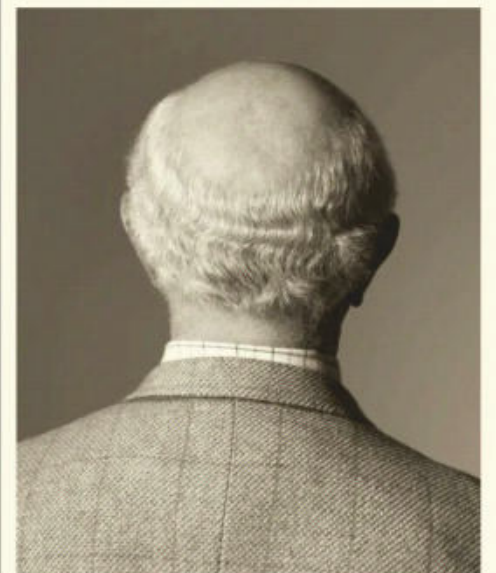
@DewhurstTony

Natural baldness is not an illness and does not need a cure.

#### Gary Macri

@garymacri

Finally, this is what all men have been waiting for. #StemCell







## ZOOLOGY

## Peas in a pod: dolphins prefer friends with similar interests

Researchers probe the social networks of marine mammals

Just like humans, it appears that dolphins prefer to hang out with others who share a common interest.

An international team of researchers made the finding at Shark Bay – a UNESCO World Heritage Site in Western Australia that's home to a large population of Indo-Pacific bottlenose dolphins (*Tursiops aduncus*).

These dolphins have previously been observed using marine sponges as foraging tools. The dolphins break the sponges off the sea floor, and then wear the marine organisms on their beak-like snouts as a protective cover as they probe the sea bed for food.

This behaviour is well-studied in female dolphins, where it's far more common than in males. This was thought to be because foraging with sponges is a time-consuming and solitary activity, and so could prevent the male dolphins from socialising with other males – an essential aspect of bottlenose dolphin life.

To find out whether this is the case, the researchers analysed the behaviour of

37 male dolphins – 13 'spongers' and 24 'non-spongers' – in Shark Bay from 2007 to 2015.

The male spongers spent significantly more time with other spongers, and this was nothing to do with whether or not they were related. In other words, it was their common interest that brought them together.

This adds a further layer of complexity to what we know about the social lives of male bottlenose dolphins, who form cooperative alliances with other males in order to gain access to females, or to keep rivals away from mating interests. These strong bonds can last for decades.

"Foraging with a sponge was long thought incompatible with the needs of male dolphins in Shark Bay – i.e. to invest time in forming close alliances with other males," said University of Bristol biologist Dr Simon Allen, who co-authored of the study. "This study suggests that, like their female counterparts and indeed like humans, male dolphins form social bonds based on shared interests."

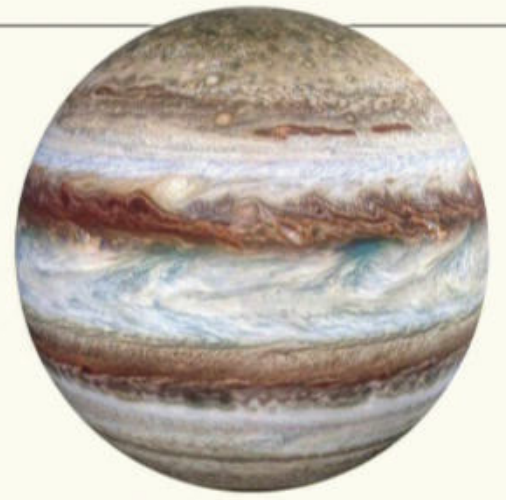


**JUPITER: A SPACE ODDITY**

Analysis of 300 stars has hinted that the gas giant Jupiter could be something of a cosmic anomaly.

Astronomers using the Gemini Planet Imager – an infrared detector attached to a telescope in the Chilean Andes – spotted six gas giant planets orbiting some of the stars they studied. But all six of

those planets were orbiting large, bright stars: not one was found around a smaller star similar to our Sun. This suggests that our Solar System might be unusual in harbouring such a large gas planet – a finding which may help astronomers to better understand how Earth formed and became habitable.

**In numbers**

# 1 IN 4

The proportion of women who admit to engaging in a 'foodie call' – going on a date with someone they are not romantically interested in simply to enjoy a free meal, according to a survey by a team at Azusa Pacific University in California.

# 100

The number of pesticides banned in the EU, Brazil and China that are still widely used in the USA.

# 22%

The amount by which job satisfaction rises when employees are allowed to take their dogs into work, as calculated by researchers at the University of Lincoln.

**ARTIFICIAL INTELLIGENCE**

# AI created to translate the cries of babies

Babies can cry because they are feeling ill or are in pain, but they will also often wail if they are feeling hungry or sleepy. This can make it very difficult for parents, especially first-timers, to know why their little ones are mewling.

×

**“There’s lots of health-related info in various cry sounds”**

Now, a group of researchers based at Northern Illinois University in the USA has employed artificial intelligence to create a method to distinguish between normal cry signals and abnormal ones, such as those resulting from an underlying illness.

The method could be useful for parents at home as well as doctors, who could use it to discern cries among sick children, the researchers say.

While each baby’s cry is unique, they share some common features. The team developed an algorithm, based on an

existing automatic speech-recognition system, to detect and recognise the features of infant cries. The algorithm incorporated a technique called compressed sensing – a process that is able to reconstruct a signal based on very sparse data, especially in environments with high levels of background noise.

The algorithm analyses the waveforms of the infants’ cries, looking for features in their loudness, pitch and timbre common to a database of recorded baby cries previously categorised by experienced neonatal nurses and caregivers. For example, The ‘neh’ sound is generally related to being hungry, because when a baby has the sucking reflex, their tongue is typically pushed to the roof of the mouth, which leads to the ‘neh’ sound. Similarly, the ‘eh’ sound means that a baby needs to burp. Generally speaking, this happens after feeding.

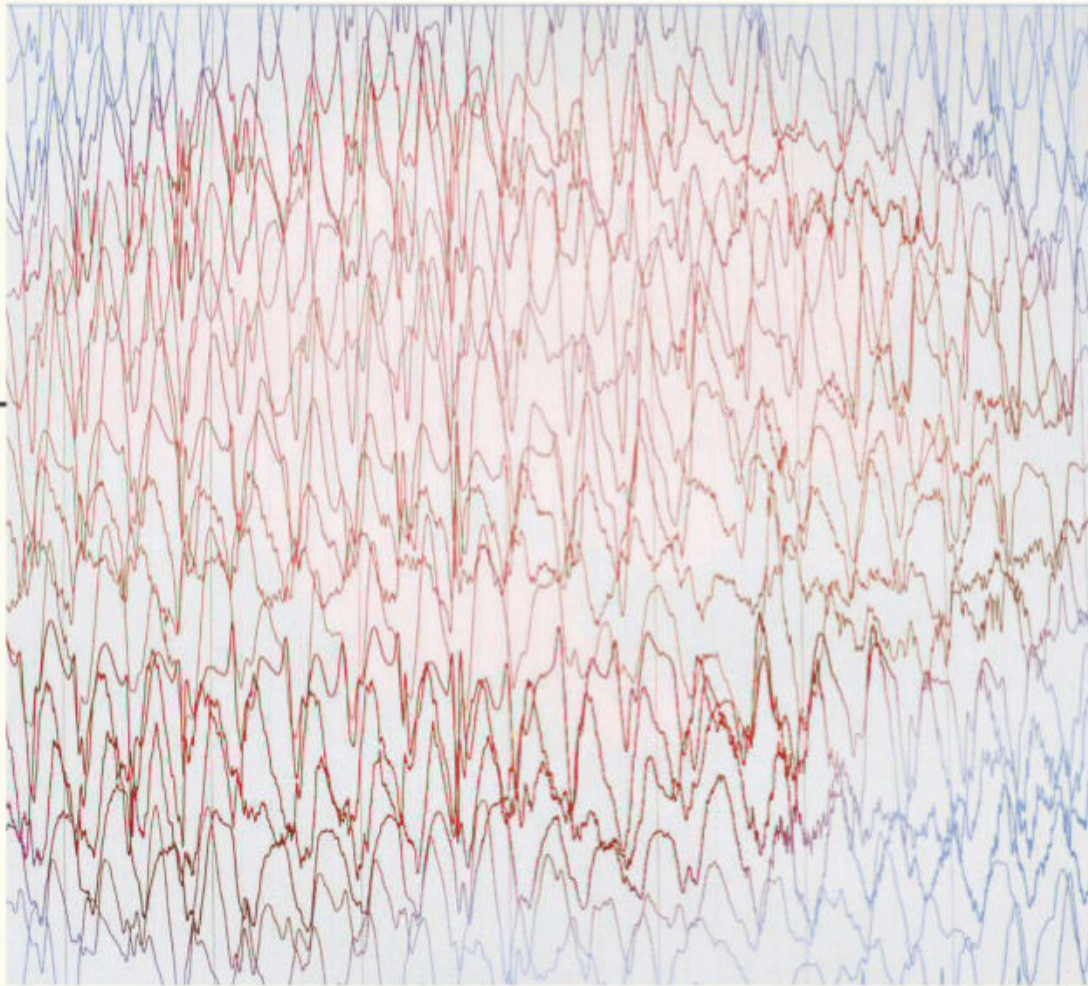
“Like a special language, there is lots of health-related information in various cry sounds. The differences between sound signals actually carry the information. These differences are represented by different features of the cry signals. To recognise and leverage the information, we have to extract the features and then obtain the information in it,” explained study co-author Prof Lichuan Liu.

The team hopes that the method could be widened out to assist with other areas of medicine in which decision-making relies heavily on experience.

“The ultimate goals are healthier babies and less pressure on parents and care givers,” said Liu. “We are looking into collaborations with hospitals and medical research centres [...] and hopefully we could have some products for clinical practice.”







Taming brain waves may offer memory benefits

## HEALTH

# Controlling brainwaves could improve memory in people with Alzheimer's

Manipulating brainwaves could become a novel treatment for Alzheimer's disease, according to neuroscientists at the University of Birmingham. The memory of people with the condition could be improved by altering the frequency of their brain waves, the researchers claim.

Brain waves, also known as neural oscillations, are the result of electrical activity: neurons fire, creating electrical signals in the brain and nervous system, and these signals can synchronise to form waves which can be detected by an electroencephalogram (EEG). Previous studies have shown that there is a link between patterns in these brain waves and the process of storing memories.

The team, led by Dr Simon Hanslmayr, reviewed the research into the topic and concluded that not only are brain waves linked to memory processes, but also that memory processes can be directly altered by manipulating brain waves. Brain oscillations act on specific neural mechanisms affecting the formation, maintenance, consolidation

and retrieval of memories. Investigating how these mechanisms are affected could help us to develop treatments for memory-related disorders. Brain waves can be forced to follow particular rhythms by various methods. "We can modulate [modify] memory performance via rhythmic neural stimulation, which can be as simple as flickering a light at a particular rhythm which then is followed by neurons in the brain," said Hanslmayr.

Brain waves can also be modified non-invasively with rhythmic sounds and electrical or electromagnetic waves. An alternative method is deep brain stimulation, in which electrodes are surgically placed into the brain. This is currently used as a treatment for Parkinson's disease and tremors.

"More research will be required, but it seems clear that driving brain rhythms [...] is a promising tool for improving memory – both for healthy people and for patients suffering from conditions such as Alzheimer's disease," Hanslmayr said.



### MIGRAINE SUFFERERS

A free app called RELAXaHEAD, made by a team at NYU School of Medicine, USA, guides people through a progressive muscle relaxation regime. With regular use, migraine sufferers experienced four fewer attacks per month, on average.

### MUSIC MAESTROS

Students who play an instrument at the start of high school (age 12) end up being an academic year ahead of their non-musical classmates in their maths, English and science skills by the time they finish high school, researchers at the University of British Columbia, Canada, have found.

## Good month

## Bad month

### SEA LOVERS

A dip in the ocean could leave us prone to infection, as skin bacteria are washed off and replaced by waterborne bacteria, a team at the University of California reports. The skin microbiome of volunteers was replaced with oceanborne bacteria for up to 24 hours after ocean swimming.

### CHICKEN CONNOISSEURS

White meats such as poultry have a similar effect on cholesterol as red meats, find researchers at the University of California. Both types increase cholesterol-enriched LDL particles in the blood, which is linked to an increased risk of heart attack.





Data crunch

# Missions to the Moon

On 13 September 1959, the Soviet Union’s Luna 2 probe became the first human-made object to reach the Moon’s surface. Since then, more than 100 missions from eight national agencies have been attempted, with around half being deemed a success. In recent years, China has been the most active nation launching lunar missions. Its Chang’e 4 mission became the first craft to land on the far side of the Moon in January 2019.

LANDING SITES

△

Luna Programme

Soviet space programme, USSR

Twenty-four robotic spacecraft were named Luna, although more were launched and only eight successfully landed.

Luna

2

Sep 1959

Luna

9

Jan 1966

Luna

13

Dec 1966

Luna

16

Sep 1970

Luna

17

Nov 1970

Luna

20

Feb 1972

Luna

21

Jan 1973

Luna

24

Aug 1976

○

Project Apollo

NASA, USA

Of the 18 missions, six succeeded in landing the first humans on the Moon.

Apollo

11

Jul 1969

👤

Apollo

12

Nov 1969

👤

Apollo

14

Jan 1971

👤

Apollo

15

Jul 1971

👤

Apollo

16

Apr 1972

👤

Apollo

17

Dec 1972

👤

○

Surveyor Programme

NASA, USA

Of the seven robotic spacecraft sent to the Moon, five successfully landed.

Surveyor

1

May 1966

Surveyor

3

Apr 1967

Surveyor

5

Sep 1967

Surveyor

6

Nov 1967

Surveyor

7

Jan 1968

MISSIONS

- Successful past mission
- Failed past mission
- Ongoing/future mission
- 👤

 Crewed missions

INFOGRAPHIC: VALENTINA D'EFILIPPO

The early years of lunar exploration were dominated by the Cold War-era rivalry between the Soviet Union and the USA. The two nations made a total of 82 attempts between 1958 and 1976.

Apollo 13 was called a successful failure. While they failed to land on the Moon, the men did return home safely.

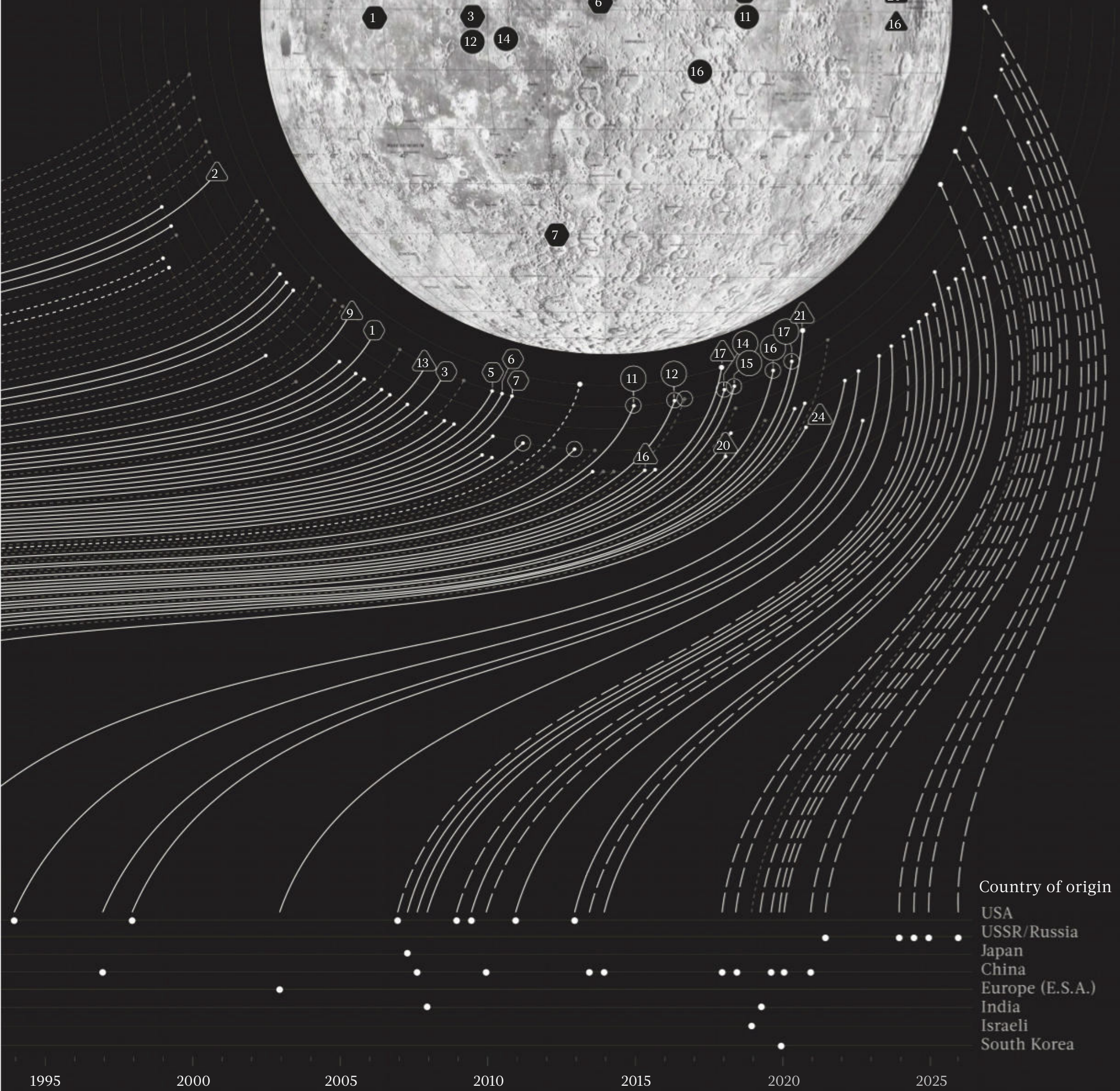


The map of the landing sites by NASA's Goddard Space Flight Center shows the locations of the many spacecraft that landed on the Moon.

- △ Luna
- Apollo
- ◻ Surveyor

Mission type

- Rover
- Lander
- Impactor
- Orbiter
- Flyby & back / Sample return
- Flyby
- Test flight



Country of origin

- USA
- USSR/Russia
- Japan
- China
- Europe (E.S.A.)
- India
- Israeli
- South Korea

1995 2000 2005 2010 2015 2020 2025



### BRAIN ENERGY LINK TO CHILDHOOD OBESITY?

American researchers speculate that childhood weight gain may be linked to the amount of energy the brain uses. Research has shown that, in five-year-olds, the brain uses almost half of the body's energy. This has implications for weight gain, which, at its simplest, occurs when someone's energy burn is less than their calorie intake.



## ZOOLOGY

# Think or swim

Seals can consciously control their circulatory systems before diving

When submarine crews in movies hear “Prepare to dive!”, they jump into action to get the vessel ready to submerge. A new study, led by Dr J Chris McKnight of the University of St Andrews, suggests seals use an equivalent thought to prompt the physiological changes needed to help them stay underwater for so long.

The team studied a group of harbour seals (*Phoca vitulina*) wearing near-infrared spectroscopy devices, which track patterns of blood circulation. These PortaSeal wearables were attached to the animals’ heads and shoulders to monitor changes in their bodies while swimming and diving in a quasi-natural foraging habitat.

“Discovering that seals can seemingly actively exert control over their

circulatory systems is really exciting,” says McKnight.

Mammals, including humans, have a range of automatic cardiovascular responses to being submerged in water, including a reduced heart rate and constriction of the peripheral blood vessels in their limbs and extremities – a process known as the mammalian diving reflex. Marine mammals exhibit this reflex particularly strongly, but we cannot see inside their bodies before and during a dive to see the extent of changes that they undergo.

McKnight and his team wondered if near-infrared spectroscopy (NIRS), used to monitor blood flow and oxygenation levels in brains, might provide the answer. It involves shining light (of wavelengths

between 800 and 2,500 nanometres) into the subject’s head and analysing the spectrum of light that reflects back. Different molecular bonds absorb different wavelengths of light, so the reflected wavelengths provide clues as to the amount of blood passing through vessels in the subject’s brain and surrounding tissue.

The results showed that seals constrict their peripheral blood vessels and boosted their cerebral blood volume about 15 seconds before diving. These anticipatory adjustments suggest that blood redistribution in seals is under some cognitive control and not simply a reflex response to submersion. Seals also increase oxygen in their brain at a consistent time in each dive, despite a lack of air.



ANIMAL WEARABLES

A tracking device weighing just one-tenth of a gram and small enough to be fixed to a bumble bee’s back was made by a team at the University of Washington.



University of Birmingham researchers have developed sensor-packed backpacks for pigeons to collect data on urban microclimates.



A white beluga whale wearing a harness with a GoPro camera holder and label suggesting it came from St Petersburg, Russia, approached a fishing boat in Norway. A defecting spy?



## Primer

# Lightyear One

**COULD THE FIRST LONG-RANGE SOLAR-POWERED CAR HERALD A NEW DAWN FOR ELECTRIC VEHICLES? PERHAPS, IF YOU WANT TO REMORTGAGE YOUR HOUSE**

## SOMEONE'S INVENTED A LONG-RANGE SOLAR-POWERED CAR?

Yep. The Lightyear One has been designed by Netherlands-based company Lightyear. The firm was founded by alumni of Solar Team Eindhoven, which won the Bridgestone World Solar Challenge race in 2013, 2015 and 2017. It was their success in the race that inspired them to develop the car and technology even further, working with people who've come from motor racing, Tesla and the aerospace industry. "We have a very different mindset, as a company," says CEO and co-founder Lex Hoefsloot. "We wanted to get into the mindset of making a super-efficient car. It's thinking about cars differently from how we used to."

## HOW LONG-RANGE ARE WE TALKING?

Compared with other electric cars, Lightyear One is pretty competitive. Worst-case scenario: in cold weather, with the heating on, at fast motorway speeds, Lightyear claims the car can manage about 400km (250 miles). In more ideal conditions, it can travel 725km (450 miles) before it needs a charge. Lightyear wanted to get rid of the issues that concern many people about electric cars, such as 'range anxiety' and a lack of charging infrastructure, so the car will reportedly charge up to 350km (217 miles) overnight from a standard 230V outlet.



**“Worst-case scenario: in cold weather, with the heating on, at fast motorway speeds, in can manage about 400km on one charge. Range anxiety begone”**

## YOU SAID IT WAS SOLAR-POWERED. WHY AM I HAVING TO PLUG IT IN?

In some parts of the world – like miserable old Blighty – you won't always be able to get by on solar power alone. Still, in the brightest two months of the year in the UK, you shouldn't need to charge it from an outlet as the car will be able to gain enough power from sunlight – though that depends on how far you need to go, of course. People living in sunnier climes can enjoy more

solar-powered driving. For example, residents of Phoenix, Arizona, could manage 224 days.

## SO IS IT COATED IN SOLAR PANELS?

Not quite. The bonnet and roof are covered in more than 1,000 solar cells. Lightyear has developed the technology to make the cells as efficient and lightweight as possible, while still being strong. They are sturdy enough, in fact, for an adult to stand on without breaking them. It will solar charge up to 12km (7.5 miles) every hour when in daylight, whether it's sitting outside your house or driving along the road. That's not bad – on a sunny day you could park up outside your work and after eight hours you'd have nearly 97km (60 miles) of charge to play with.

## WHAT DOES IT LOOK LIKE?

Lightyear wanted to create a car of the future, and its sleek lines certainly deliver. From its reduced weight and drag, to a small battery, everything has been optimised to make it as efficient as possible. Plus, it's got the mod cons you would expect, like Apple CarPlay and Android Auto. There's also a 230V power outlet inside, which, according to Hoefsloot, essentially turns the car into "a power bank with solar cells on the roof". The company is also sharing its technology with other manufacturers.

## HOW FAST DOES IT GO?

Top speed is 160km/h, so about 100mph.

## AND THE COST?

You can reserve one for a hefty €149,000 (£133,000). Hoefsloot is optimistic that prices will drop as production increases. "If we push energy consumption down, and therefore energy cost, and maintenance costs down, then you will get to very low costs per kilometre," he says. "And this is the strategy we are using to get to super-affordable price points in 10 to 15 years."





**Prof John Britton** epidemiologist

## Horizons

# THE TRUTH ABOUT E-CIGARETTES

**San Francisco recently became the first US city to ban sales of e-cigarettes, citing the fact that the long-term health effects of vaping are still unknown and that there seems to be an upswing in young vapers. However, some people believe this decision may turn former smokers who now vape back onto traditional tobacco products.**

### WHAT DO YOU MAKE OF SAN FRANCISCO'S RECENT DECISION TO BAN THE SALES OF E-CIGARETTES?

It's not something that's happening anywhere else in the world. I think the USA generally and San Francisco particularly is getting into something of a moral panic. What they have had, over the last year, is a big increase in the use of a particular product which delivers very high amounts of nicotine. It looks like a USB stick and you charge it like a USB stick. So, quite a novelty product.

And that hasn't been a problem until last year's data came out, because smoking prevalence rates have been falling in children in America just as they have in the UK, but the 2018 figures had a slight uptake with a big increase in vaping, and so that has been interpreted as a sign that vaping is producing a whole new

generation of nicotine addicts. And on that basis they've banned it.

### WILL THIS PROVE EFFECTIVE?

I think it's a gross overreaction, but the USA does have a problem in that it has never endorsed the use of electronic cigarettes as a way of quitting smoking in the way that we have in the UK, and it has never prohibited advertising [e-cigarettes] to children, and the brand in question has been advertised strongly on social media to young people.

So, in effect, you get what you ask for and that's what's happened. But the solution of banning the sale of e-cigarettes strikes me as being utterly unenforceable, as you just go out of the city to buy them, so how do you then achieve anything? The problem is advertising nicotine products to children and selling them to children, not the fact that these products are harmful to society as a whole.

### PEOPLE MENTION THAT THE FLAVOURS OF E-CIGARETTES, LIKE MANGO OR CHERRY, FOR EXAMPLE, MAKE THEM MORE APPEALING TO CHILDREN

There may be some truth in that, but it's also true that most smokers – and I've never been a regular smoker, so I find this hard to believe – say that they find the sensation of inhaling nicotine vapour quite difficult to cope with. And the flavour makes all the difference for many vapers between being able to use the product. So, again, it's important not to throw the baby out with the bathwater. You can ban flavours, and protect children, but then you stop hundreds and thousands of smokers from successfully transitioning to something that's going to prolong their life.

### IN THE UK, THE NHS ACTUALLY RECOMMENDS SWITCHING TO E-CIGARETTES IF YOU WANT TO STOP OR CUT DOWN ON SMOKING TOBACCO

Yes, the most effective way to quit smoking is to use nicotine replacement therapy, and electronic cigarettes. There was a trial published in the world's leading medical journal, which happens



×

**“You can ban flavours, and protect children, but then you stop hundreds and thousands of smokers from transitioning to something that's going to prolong their life”**

GETTY





to be an American one, the *New England Journal Of Medicine*, showed that in a randomised trial in the UK, people in smoking cessation services who are allocated to e-cigarettes in addition to conventional nicotine replacement therapy are about twice as likely to quit. And they are effective quitting agents, so we should be promoting them.

**IT ALSO HELPS THAT E-CIGARETTES GIVES A SIMILAR SENSATION TO TRADITIONAL TOBACCO PRODUCTS...**

Most smokers want to quit smoking. All smokers know that it's harmful but they find it difficult to find something that is an effective substitute to smoking. You need decent amounts of nicotine to be delivered, which most nicotine replacement therapies alone don't do, and you also need to have the essential behaviour stimulation, like sharing cigarettes with friends. You can go out with other people and smoke and vape

and you're not ostracised. You don't go out with a group of smokers and stick a nicotine patch on your arm and say 'hey, that seems cool, we're sharing nicotine together'. It looks stupid.

**USING E-CIGARETTES ISN'T WITHOUT RISK THOUGH, IS IT? WHAT DOES THE CURRENT RESEARCH SAY?**

They aren't new. They've been around for 15 years; they've been in widespread use in the UK for about seven years. There's been no appreciable reported adverse effects, with use by millions of people. So, if that was a drug, you'd be pretty confident that there are no major adverse short-term effects.

Long-term, because you're inhaling a hot vapour which has got foreign materials in it into your lungs, it is likely that there will be some lung damage from it. But, if you look at the levels of these things, you will see that the levels are a fraction of those of tobacco smoke. So on the one

hand, it's completely barmy, for you or I as non-smoking, non-nicotine users, to start using e-cigarettes. But if you're a smoker, it's a no-brainer. You should switch.

**BUT THEY CONTAIN NICOTINE, SO ISN'T THAT GOING TO CAUSE DAMAGE TO YOUR CARDIOVASCULAR SYSTEM, ETC?**

No, it isn't. If you look at the general physiological profile of effects of nicotine on the body, it's on a par with caffeine. So, you have maybe 80 per cent of the British population being addicted to caffeine. I've had discussions with people telling me how electronic cigarettes are harmful because they contain nicotine, while drinking coffee.

---

**PROF JOHN BRITTON**

*John is director of the UK Centre for Tobacco & Alcohol Studies at the University of Nottingham..*

**Interviewed by BBC Science Focus commissioning editor Jason Goodyer.**



## PHOTOGRAPHY

# Science's hidden stories

The shortlist of 28 images for the annual Wellcome Photography Prize competition has been announced. Here are a few of our favourites from this year...

1



## 1. Katie's New Face *Lynn Johnson*

Aged just 21, Katie became the youngest person ever to receive a full face transplant. This shot shows her new face moments after it was surgically removed from the donor. The procedure was carried out at Cleveland Clinic in Ohio and took 30 medical professionals more than 30 hours to complete.

## 2. Zora The Robot Caregiver *Dmitry Kostyukov*

The United Nations predicts that the number of people over the age of 60 will reach 2.1 billion by 2050. Health services will struggle to meet the needs of ageing

populations, and new technologies such as this robot may offer ways to provide care. The robot, named Zora, can be controlled remotely by a healthcare professional. This picture was taken at a nursing home in Jouarre, France, where Zora can help patients with communication, and offer comfort and entertainment – even exercise classes. Some people ignore the robots, but others develop an emotional attachment to them.

## 3. Awake Heart Surgery *Tom Parker*

Since 1999, more than 600 people have undergone a pioneering form of open-heart surgery at

Wockhardt Hospital in Bangalore, India. Instead of using a general anaesthetic, the patient's body is numbed using an epidural to the neck. This means doctors get a better idea of how the patient's body is reacting, and even allows communication with patients during the operation.

## 4. Shroud *Simon Norfolk and Klaus Thymann*

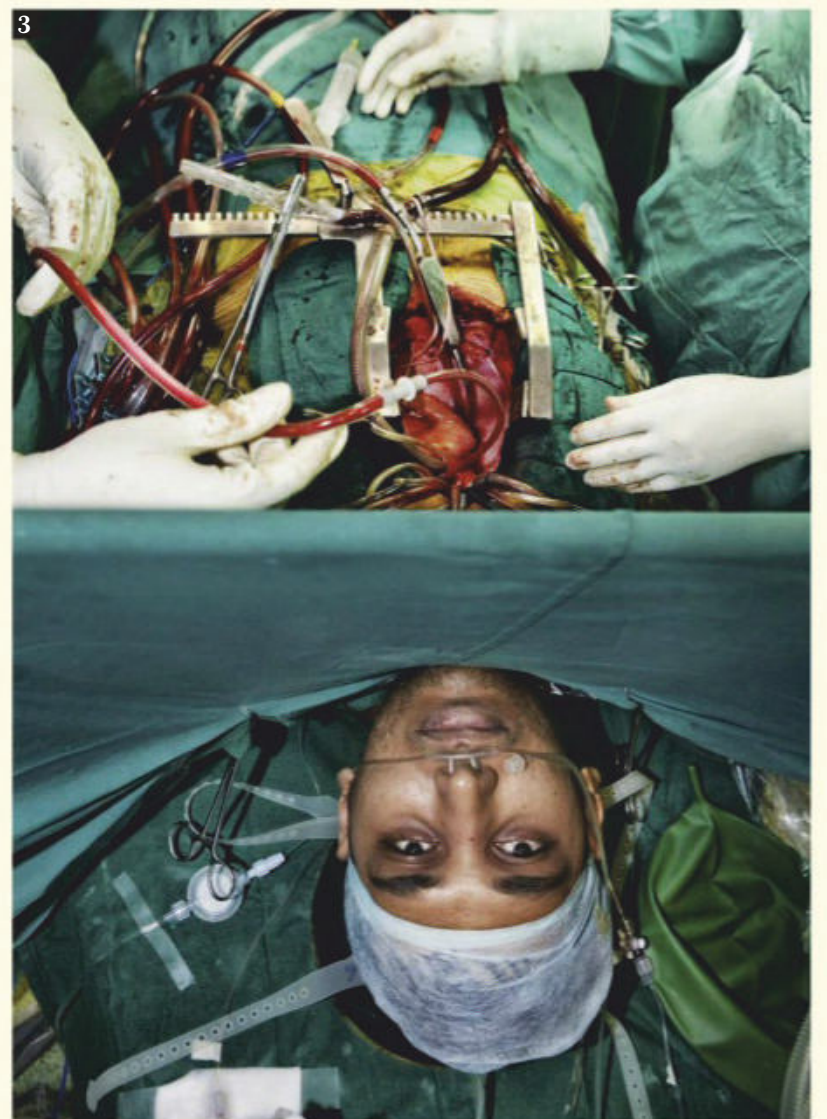
This shot shows an ice grotto at Rhône Glacier, Switzerland, run by a family as a tourist attraction. Thanks to rising global temperatures, driven by human activity, the glacier is melting. To

protect it, and their livelihood, the family has covered part of the glacier with white geosynthetic blankets in an attempt to reflect away the Sun's heat.

## 5. Pakistan Floods *Daniel Berehulak*

Record levels of rain during 2010's monsoon season caused flooding across Pakistan. Countless homes, crops and workplaces were destroyed. Estimates of the number of people killed range from 1,200 to 2,200. This aerial photograph shows the inhabitants of a flooded village in the Dadu district scrambling for food rations as they battle the wind whipped up by an army helicopter.







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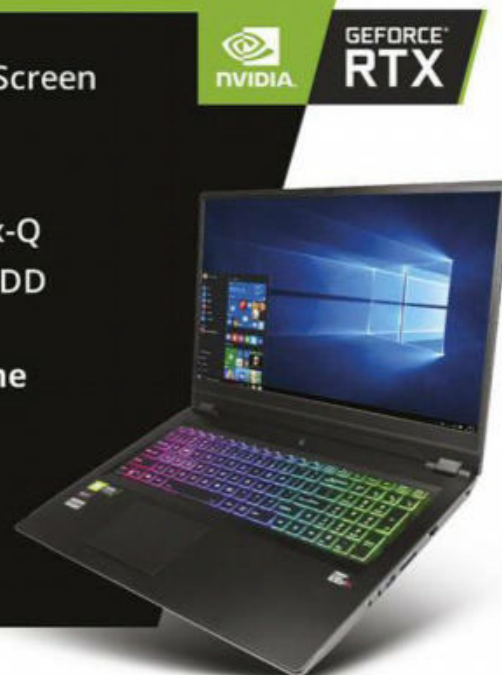
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1 REVIEW

PLASTIC: CAN I  
REDUCE HOW  
MUCH I USE?

With the UK government admitting it won't hit its 2020 recycling targets, we find out how you can navigate the recycling minefield.

Choose your bags carefully

The 5p charge for single-use plastic bags first came into effect in Wales in 2011. Northern Ireland and Scotland followed suit, and finally England joined the effort in 2015. The idea was to discourage shoppers from using new bags every time they shopped, and it had an enormous effect: since then, the measure is estimated to have reduced the number of single-use bags by 13 billion in England alone.

Biodegradable bags, designed to be broken down by bacteria, are generally thought to be a kinder option for the environment. However, they need specific conditions to be broken down: a study by the University of Plymouth found that biodegradable bags left in soil or in a marine environment could still hold a full bag of shopping after three years.

Cotton tote bags aren't necessarily better. Cotton is environmentally intensive to produce, between the energy, water, fertiliser and pesticide used in the process, and on top

1 While plastic food packaging is often not necessary, in some cases it can help extend shelf life and reduce food waste

2 Single-use carrier bags have declined in popularity, with many people opting for alternatives





of that, it can't be recycled. A 2018 Danish study found that a cotton bag has to be reused over 7,000 times to have the same environmental impact as a single-use plastic bag. Take note, however, that littering was not included in the study as one of the environmental impacts.

Whatever you pick, the take-home message is to use it as much as possible until it falls apart.

## Maximise your recycling

A 2018 study from the University of Leeds found that only 16 per cent of household plastics collected for recycling ended up being sent for processing. According to Dr Sharon George, lecturer in green technology and environmental sustainability at Keele University, many local authorities don't have the facilities to recycle all types of plastic, and so much of the waste ends up being incinerated in waste-to-energy plants instead. "That plastic is going to at least displace fossil fuels, and it's not ending up in the environment," she explains.

According to George, we can make sure that the right things are getting recycled by being a bit more vigilant. Plastic recycling can easily be contaminated with the wrong

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type of plastic. "A lot of waste gets rejected because it's been contaminated with plastic or other materials that shouldn't be in there," George says. Food packaging is especially susceptible to contamination, which hinders recycling. "This is a big reason the value of the waste goes down," says George. "It can be contaminated by just not being washed out."

Removing the contaminants from the rest of the material also causes problems: according to an analysis of recycling contamination by analytics firm Croner-i, attempting to remove a single contaminant takes several kilograms of recyclable material along with it.

The biggest thing you can do is be aware of what can and can't be recycled in your local area, says George. Don't assume that something can be recycled just because it's plastic. "That definitely makes it worse, because that can then potentially mean that a whole collection then gets rejected, and either incinerated or sent to landfill," she explains.

## Reduce your food packaging

Every year, the average European citizen throws out 30 kilograms of plastic food packaging. There are the more obvious offenders, such as a 'cauliflower steak' – a single slice of cauliflower on a plastic tray, in a plastic wrapping – but there are many products that come unnecessarily wrapped. Try buying fruit and vegetables loose where possible. Waitrose announced in June that a store in Oxford is trialling a selection of packaging-free groceries, including pasta and rice, beer and wine, and some cleaning products, to encourage shoppers to bring their own containers.

Also bear in mind that less packaging is not necessarily better: recyclable material is key. "If you know, then, which bits of plastic can be recycled, it might make you



think at the checkout whether what you've got in your basket is recyclable," George says. "If you've got a choice between two items and one is in a container that you can recycle and one is in one that you can't, go with the one you can."

## Single-use food packaging isn't always bad

Many foods can survive transportation without being wrapped in plastic. However, for certain foods, a cellophane wrapping or a plastic container can vastly extend shelf-life. Cucumbers, which last only three days unwrapped, can stay fresh for up to two weeks in a plastic wrapping. New potatoes in a plastic bag last longer, and keeping grapes in plastic containers catches the fruits that fall off the stems, reducing waste by 20 per cent.

by **SARA RIGBY**

Sara is the online assistant for BBC Science Focus. She has an MPhys in mathematical physics.

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## 2

## ANALYSIS

## SUN CREAM: IS IT A RISK TO YOUR HEALTH?

A number of recent studies have painted sun cream in a bad light. We take a deeper look at the science of protecting your skin from sunshine.



**M**elanoma skin cancer is the fifth most common form of cancer in the UK, and according to Cancer Research UK, 86 per cent of the 16,000 new cases every year are preventable. However, sunshine also has proven benefits to our health. Could our reliance on sunscreen be denying us these?

Our bodies need sunlight to help us create vitamin D. While some is absorbed from food, most

of it is produced via a chemical reaction in our skin that relies on the energy from ultraviolet (UV) rays. The amount of vitamin D you have governs how much calcium your body absorbs. Not enough vitamin D can lead to diseases like rickets and osteomalacia, where bones are left soft, weak and warped.

Unfortunately, the UVB rays that help our bodies create vitamin D also cause sunburn, skin ageing and skin cancer. So, using sun cream daily

While it's sensible to avoid sunburn, our bodies do need a little unprotected exposure to the sunshine to get enough vitamin D

throughout the summer months – assuming it's applied correctly and regularly – could theoretically block the body's best access to vitamin D.

What's more, some dermatologists believe that just as important as vitamin D, if not more so, is nitric oxide. Also created in the body after exposure to UV light, nitric oxide causes blood vessels to relax and expand, lowering blood pressure. Dr Richard Weller, a dermatologist who studies the effect of sunlight on



blood pressure at the University of Edinburgh, said of his research in 2013: “We suspect that the benefits to heart health of sunlight will outweigh the risk of skin cancer.” Weller also appeared on the BBC’s *Trust Me, I’m A Doctor* in 2016, suggesting that there’s no reason to avoid sunlight, just don’t get burnt.

Further doubt over sun cream arose with a study published in the *Journal*

not a sensible form of sun protection: it provides a sun protection factor [SPF] of around only 3 and leaves a trail of DNA destruction in its wake.”

Does this mean we should avoid the sunshine entirely? “The fact that humans have evolved melanin shows that sunlight isn’t wholly good,” explains Lyman in an email. “But also the fact that humans have evolved to have less melanin the further

**“A suntan is not a sensible form of sun protection: it provides a sun protection factor [SPF] of around only 3 and leaves a trail of DNA destruction in its wake”**

Of The American Medical Association in May. The Maryland-based team found that active ingredients in four types of sun cream found their way into the bloodstream after one day of use. While this sounds scary, it’s not known whether sunscreen ingredients such as oxybenzone and octocrylene have any effect in the body. Even if they do, that doesn’t necessarily mean that the average person would be affected: the participants in the experiments followed the maximum guidelines of their sun creams for four days, applying four times a day. On the other hand, a study from King’s College London in 2018 found that, in everyday use, people usually apply less than half the recommended amount of sun cream. The Maryland researchers suggest that you don’t throw out your sun cream until we have a better idea about its effects.

Whether or not sun cream comes with risks, the danger of sunlight is well proven. “There is overwhelming evidence that skin damage, even from mild tans, accumulates over the years,” writes Dr Monty Lyman in his book *The Remarkable Life Of The Skin*. “Even though melanin is the original sunscreen, a suntan is

they have moved away from the equator shows it has some benefits! Essentially, there are benefits and risks with sunlight, and a balance needs to be struck.”

The optimal amount of time spent in the sunshine to get enough vitamin D depends on your skin tone, says Lyman. As a rule of thumb, between March and September, half the time it takes for your skin to burn, two or three times a week, is enough unprotected time to get all the vitamin D you need. He adds that we should spend time outside every day for personal wellbeing, and there is no need to actively seek the sunshine to ‘top up’ vitamin D.

This is especially true when holidaying somewhere hot: a recent study published in the *British Journal Of Dermatology* showed that using high-SPF sun creams doesn’t prevent vitamin D production when sunlight is strong. While there might be much more to learn about the risks of sun cream, there isn’t the evidence to suggest we should ditch it yet.

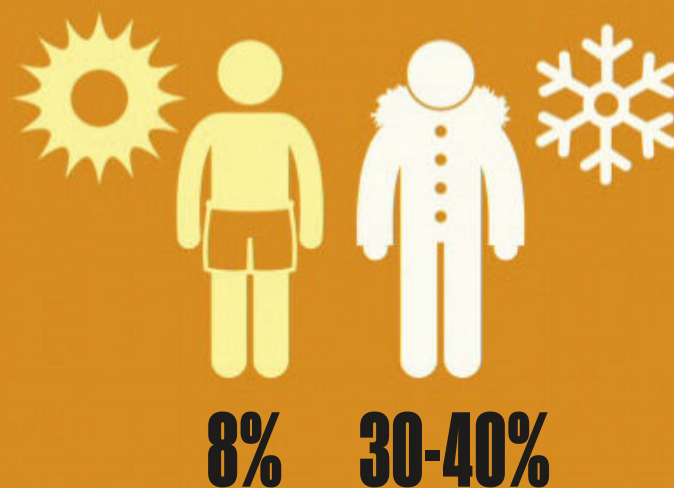
by **SARA RIGBY**

Sara is the online assistant for BBC Science Focus. She has an MPhys in mathematical physics.

NEED TO KNOW  
Sun worshippers and  
avoiders take note

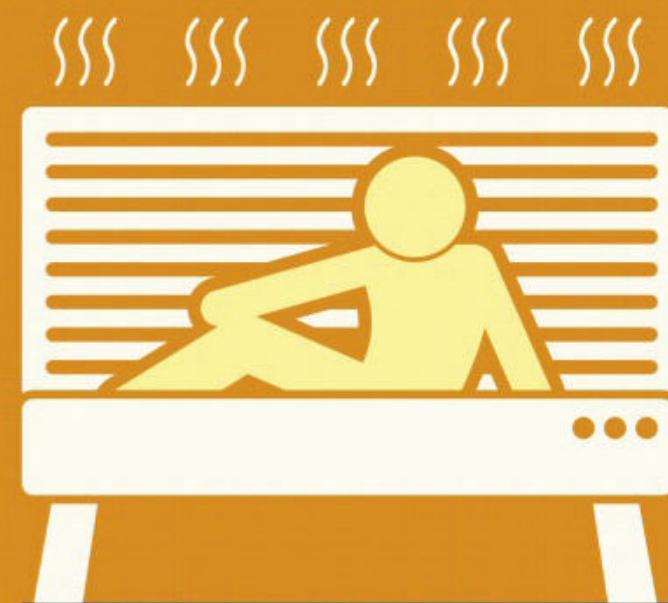
## D-DEFICIENCY

At the end of the summer, 8 per cent of UK adults are vitamin D deficient, compared with 30 to 40 per cent during the winter.



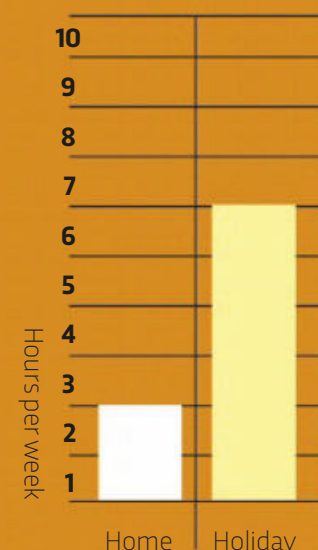
## BURNING ISSUE

Using sunbeds can increase your risk of melanoma skin cancer by 16-20 per cent



## SUMMER HOLIDAYS

In the summer, people in the UK spend an average of 1-2 hours per day outside. On holiday, this swells to 5-6 hours.





## 3 COMMENT

ULTRA-PROCESSED FOOD:  
WILL FISH FINGERS AND  
FIZZY DRINKS KILL YOU?

A new study found that eating ultra-processed food could increase the risk of death by 62 per cent. But is this as bad as it sounds?

There is a truth universally acknowledged that the latest health research must be reported in dramatic and anxiety-inducing language. Some recent studies into ultra-processed foods (like fish fingers, fizzy drinks and ready meals), published in the *British Medical Journal*, made for alarming headlines. *The Sun* told us that “just four portions of processed food a day could

Ultra-processed foods, like ready meals, will probably not lead to instadeath, as some headlines claim





kill you”, while *The Telegraph* said that ultra-processed foods “could increase the risk of early death by 60 per cent”.

As is often the case, the research is well-designed and cautious. What’s more, the news coverage is not exactly false. The problem is that the numbers driving the headlines are hard to interpret, and seem more frightening than they are. Let’s unpack what the evidence means in this case.

Spanish researchers followed roughly 20,000 students over 14 years, using questionnaires to estimate how many portions of ultra-processed food they were eating every day. They found that those who ate the most ultra-processed foods had a 62 per cent increased risk of death from any cause, compared with those who ate the least. If we assume the conclusions are accurate, then a 62 per cent increased risk of death sounds pretty shocking. But what does it mean?

Let’s imagine two friends – Wanda and Winona. They’re both around 50, the same weight, do the same amount of exercise, have same family histories of disease, but not the same habits or lifestyle. Wanda is keen on instant noodles, fish fingers and fizzy drinks, while Winona prefers steamed vegetables and wholemeal sourdough. Each one faces an annual risk of death, whose technical name is their ‘hazard’. The key statistic reported in the Spanish study was a hazard ratio of 1.62. This means that, for two people like Wanda and Winona who are similar apart from their different diets, the one with the risk factor – Wanda – has a 62 per cent increased annual risk of death over the follow-up period (around 14 years in the Spanish study).

It’s tempting to interpret this as meaning that Wanda’s life is going to be 62 per cent shorter than Winona’s, but that’s not what’s going on. Crucially, the risk of dying in any one year for the average person is pretty low, so a 62 per cent annual increase in risk of death may not be as alarming as it sounds. In the UK, for example, the average annual risk of death for 50-year-old women is around 0.2 per cent, which means you might expect 2 in every 1,000 women like Winona to die each year. A 62 per cent increase on that number gives around a 0.3 per cent annual risk of death, which would be 3 in every 1,000 women

like Wanda. The difference, 1 in 1,000, sounds a lot less alarming than the 62 per cent which made the headlines.

So what should a cautious consumer make of all this? Should you change your diet? A major caveat is that the study only shows an association between consuming ultra-processed foods and a higher risk of death – it doesn’t prove what’s causing it. The headline in *The Sun* is misleading – it might not actually be the fish fingers and filo pastries to blame. That’s because the group consuming the highest proportion of ultra-processed foods may have been on average poorer, or exercised less, or smoked more than the group consuming the lowest proportion.

The researchers always carefully try to take these ‘confounders’ into account when they do their analyses (and this study did factor in a long list of them), but it’s fiendishly difficult to be certain you have fully removed their influence, and it’s always possible that there’s a lurking factor that you have missed.

That doesn’t mean that the study should be ignored. It definitely counts as evidence that ultra-processed food isn’t good for your health, even if it doesn’t prove a causal relationship. But it may not be a good idea to wait for definitive proof before cutting back on the Turkey Twizzlers.

by ILAN GOODMAN and  
 PROF DAVID SPIEGELHALTER  
*Ilan and David are based at Cambridge University’s  
 Winton Centre for Risk and Evidence Communication.*

## × “It may not be a good idea to wait for definitive proof before cutting back on the Turkey Twizzlers”

### FOLLOW THE CONVERSATION



#### @timspector

Tim is a professor of genetics who researches and writes about the microbiome, and unpicks the relationship between food and health.



#### @saraheeberry

Sarah is a doctor of nutritional sciences at King’s College London.



#### @alex\_freeman

Alex is executive director at the Winton Centre for Risk and Evidence Communication at the University of Cambridge.



#### @Sander\_vdLinden

Sander is an assistant professor in social psychology at the University of Cambridge. He studies the psychology of social communication, and the spread of fake news.



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# PRACTISING

AHEAD OF THE 50TH ANNIVERSARY OF THE APOLLO MOON LANDINGS, WE LOOK AT THE INNOVATIVE TRAINING AND EXERCISES THAT PUT THE ASTRONAUTS THROUGH THEIR PACES IN PREPARATION FOR THEIR ICONIC MISSION

WORDS: AMY SHIRA TEITEL

BBC  
TWO

## STARGAZING: MOONLANDING SPECIAL

Prof Brian Cox and Dara O Briain travel to where the historic Apollo 11 mission began. They meet astronaut General Charlie Duke who shares what it was like to guide Neil Armstrong and Buzz Aldrin to the surface of the moon, and how he followed in their footsteps three years later. Check *Radio Times* for more details.



# ON THE MOON

## WALKING UP THE WALL

LUNAR LANDING  
RESEARCH FACILITY,  
VIRGINIA

Astronauts on the Moon would be working in reduced gravity – about one-sixth of what we feel on Earth. One way that NASA tried to replicate this experience was with this Reduced Gravity Walking Simulator. The puppetry-like suspension system kept astronauts in a horizontal position at the bottom of a long pendulum, which was designed so that the vertical ‘floor’ supported one-sixth of their weight. As the astronauts walked, jumped and ran, researchers could study factors such as their speed, energy use and fatigue levels. The test subject here is working in a near-complete spacesuit so that engineers could learn more about the challenges of moonwalking with constrained movement, which helped them design suits that prevented astronauts from overheating on the Moon.





LUCY HARRISON / BBC



## ONE SMALL PRACTICE STEP

← MANNED SPACECRAFT CENTER (NOW THE JOHNSON SPACE CENTRE), HOUSTON, TEXAS

Neil Armstrong and Buzz Aldrin would spend about two-and-a-half hours on the lunar surface during their Apollo 11 moonwalk, every minute of which was meticulously planned. In April 1969 – three months before their trip to the Moon – the astronauts donned their heavy spacesuits and carried out a dress rehearsal.

On a mock lunar surface, they planted the American flag, practised gathering rock and soil samples, and determined how and where they would deploy scientific instruments such as the Passive Seismic Experiment, designed to detect moonquakes. They also practised descending the Lunar Module's ladder, with Armstrong rehearsing his famous “one small step” onto the Moon's surface.

## SURVIVAL OF THE COOLEST

RENO, NEVADA ↓

One of the grand ironies of Apollo-era spaceflight was that the astronauts, all expert pilots, returned to Earth in a capsule that fell with little directional control. This meant that, in an emergency or due to some error, it was possible a mission could land a long way from its target spot in the ocean, perhaps even landing in one of the world's deserts.

To prepare for such an eventuality, astronauts studied desert survival. Though they had some rations in the capsule, they were taught how to survive off the land and use what materials they had to fashion a shelter. Here, astronauts Frank Borman, Neil Armstrong and John Young, and NASA official (and ex-astronaut) Deke Slayton, demonstrate how to use parachute material to stay cool in the punishing desert heat during a training session in August 1964.





# LET ME DOWN GENTLY

EDWARDS AIR FORCE BASE, CALIFORNIA

This alien-looking contraption is the Lunar Landing Research Vehicle (LLRV) – a barebones approximation of the Lunar Module that would carry astronauts to the surface of the Moon. Designed to mimic the feel and movement of a vertical lunar landing, the LLRV was little more than a cockpit mounted above a large engine. Sixteen small thrust rockets provided directional control, while the main engine gave enough thrust to make the pilot feel like he was flying in low gravity. Neil Armstrong is seen here with the LLRV in 1964.

It was an excellent simulator that NASA brought into training early on, but the vehicle was not without its problems. During one test in May 1968, Armstrong ran into difficulties and was forced to eject moments before the LLRV crashed and caught fire. Thankfully, he walked away unscathed. An improved version of the trainer, the Lunar Landing Training Vehicle (LLTV), resumed flight operations not long after.











## SPLASHDOWN

GULF OF MEXICO ↑

Each Apollo mission ended with a splashdown as the Earth-bound capsule fell by parachute onto the yielding surface of the ocean. This was simply the easiest way to end a spaceflight (and it still is – SpaceX and NASA both plan to use this method for their upcoming Dragon and Orion missions). This meant astronauts had to learn how to safely exit the waterborne capsule. They needed plenty of practice beforehand, because when it came to the real situation they would have just experienced a harrowing 11-minute drop through the Earth's atmosphere. First, the astronauts practised in pools where they could easily swim from the spacecraft. Then they moved into the ocean where waves and weather made things more challenging. Here, the Apollo 11 crew practises exiting a mock-up spacecraft in the Mexican Gulf. Over time, astronauts got used to transferring from the bobbing capsule into the life raft, from where they would be winched into a helicopter and delivered to the safety of an aircraft carrier.

by AMY SHIRA  
TEITEL

(@AmyShiraTeitel)

Amy is a spaceflight  
historian and science writer.  
Her YouTube channel is  
Vintage Space.

## DRESS REHEARSAL

CAPE KENNEDY (NOW CAPE CANAVERAL), FLORIDA →

Every Apollo spacecraft – made up of the Command and Service Module and the Lunar Module – flew for the first time on its lunar mission. This meant that the Apollo 11 crew had limited time to train in the actual modules, and so did most of their pre-flight work in sophisticated simulators such as the one shown in this montage. These specialised trainers were designed to mimic actual flight conditions as closely as possible. For example, when an astronaut fired a thruster engine, the readouts in the simulator responded accordingly, video-based visuals in the windows reflected the movement of the spacecraft in space, and hydraulic lifts simulated the physical motion of the craft. There were multiple simulators at the principle NASA centres where astronauts trained. The challenge for the engineers was to update the simulators as tweaks were made to the real-life modules. But they succeeded, amply preparing Apollo crews for their lunar missions. **SF**









# SPACE EXPLORATION: THE NEXT 50 YEARS

SINCE APOLLO 11, WE'VE LANDED ROBOTS ON MARS, BUILT A BASE IN ORBIT AROUND THE EARTH, AND SENT PROBES BEYOND OUR SOLAR SYSTEM. HERE, SCI-FI AUTHOR **STEPHEN BAXTER** SPECULATES ABOUT WHAT MIGHT BE ACHIEVED IN THE NEXT FIVE DECADES, WITH ILLUSTRATIONS BY SCI-FI ARTIST **MITCHELL STUART**









**T**he previous decade is when it begins.

In March 2019, US Vice President Mike Pence publicly challenges NASA to mount a crewed return to the Moon before the end of 2024. This would be the last year of a second term for President Trump, and so an echo of President Kennedy's call for a Moon landing before the end of the 1960s, which led to the Apollo programme.

The NASA of the 2020s is not the young and nimble organisation of 1960. However, the challenge is accepted.

In fact, NASA, with its overseas partners, has already begun the development of a new lunar architecture. This depends on a heavy-lift launcher called the Space Launch System, which is a rival to the Saturn V; an Apollo-like spacecraft being developed with the Europeans; and the Lunar Gateway, a space station in lunar orbit, from which astronauts could descend to the surface. All that is missing is a lander, a new Lunar Module. But the private company





Blue Origin steps up to the plate, with a design it has been developing since 2016.

And so the first lunar mission since Apollo launches in late 2024.

By now, however, the decade of the Moon is in full swing, with previous visits from automated landers and rovers launched by a variety of countries, including the Europeans, Japan, India, and – most ambitiously – China, which attempts sample-return flights. Still, it is believed that the majority of humankind watch or listen on 13 November 2024 – just inside Pence's deadline – as NASA astronauts Jeff Krauss and Kauai Pukui begin their cautious descent towards the Mare Imbrium, the first lunar crew since Apollo 17...

In the year 2029, 60 years after Apollo 11, a Chinese crew lands on the surface, respectfully close to the site of the 2024 US landing attempt. The 'Pence mission' had always been premature. Krauss and Pukui were not the first to land on the Moon, but, six years after their disastrous descent, they are the first to be buried there.



### THE SPACEPLANES

In the early days of space exploration, expensive launchers like the Saturn V were thrown away after one use. A true spaceplane would take off unassisted from a runway, reach orbit, then return to land. (This is called 'SSTO' – single stage to orbit.)

The major issue is that such a craft can't carry all its own fuel, and the oxidiser to burn that fuel. A jet engine must collect oxygen from the air, but if the craft itself is travelling faster than sound, the intake of air creates drag. In 2025 that the first true SSTO flies. Skylon's engine works like a conventional jet up to five times the speed of sound, at which point the engine switches to an internal liquid oxygen supply. Other competitors aren't far behind. True space tourism briefly blossoms, before becoming deeply unfashionable in a new age of climate management.







### THE MOON BASES

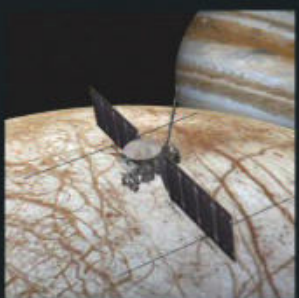
Back in the 1970s, the apparent lack of water in Apollo Moon rock samples had been a grave disappointment. Water could have been cracked into

hydrogen and oxygen to supply breathable air and rocket fuel. Without water, the Moon was much less interesting a destination.

But by 2020 extensive water deposits had already been discovered in wide areas of the Moon, in the form of hydroxyl compounds. And in 2028 a dramatic Chinese discovery of easily accessible water-ice in the shadows of the lunar north pole suddenly revived old optimism, and old colonisation studies are dusted off.

By now astronauts from many nations have reached the Moon: the US, China, Europe, Japan, Russia, India. And from the first landing sites colonies have quickly developed, extracting metals and other materials for various purposes, including the manufacture of heavy components of habitats and Mars ships. The endless, unshielded sunlight is an obvious energy resource.

But the detachment from Earth grows. The principles of outer space law are still upheld: you can exploit lunar resources, but there is no sovereignty. No nation owns the Moon. The colonists are happy about that. And through the decade, the colonists increasingly look to the future, rather than the past: to the Moon, rather than ties to Earth.



### ROBOTIC EXPLORATION

Two large, expensive and elderly probes finally reach Jupiter in this decade: NASA's Europa Clipper, set in orbit around Jupiter to make multiple flybys of the potentially life-bearing moon Europa; and ESA's JUICE, the

Jupiter ICy moons Explorer, sent to study the moons Callisto and Ganymede, along with Europa. The probes are magnificent and return good science. But, having been designed and largely built before 2020, they now seem too big, too heavy, and frustratingly dumb – in contrast to a new generation of small, smart, highly capable probes already being sent out to explore the asteroid belt and beyond.





Part Two.  
The Decade  
of Mars

# MISSIONS TO MARS

2030

2039

“THE LANDING SITE  
ON MARS IS IN THE  
ARES VALLIS”

The 2030s is the decade in which humans finally land on Mars – using a technology strategy already decades old. Back in 1990 a team of engineers led by Robert Zubrin presented NASA with a new plan to get people to Mars, called ‘Mars Direct’. The core of it was a scheme to manufacture rocket fuel on Mars, by using the Red Planet’s carbon dioxide air to make methane. Removing the need to carry the propellant for a return journey all the way to Mars reduces the mission size and cuts costs. The mission unfolds across several launch windows. First, an uncrewed Earth Return Vehicle (ERV) is sent to Mars, along with an automated factory for manufacturing the methane propellant. The stratagem is designed for safety. The human crew do not launch until their return ship is safely on Mars and fuelled up.

At last, on 4 April 2038, a crew drawn from four nations – the US, Russia, China, and the European Federation – travelling in a ship assembled at Lagrange Station in Earth orbit, lands on Mars. (Turn the page for more information on Lagrange Station.) And Zubrin lives to see his vision fulfilled. The landing site is in the Ares Vallis, close to the remains of NASA’s Pathfinder probe. This echoes the achievement of Apollo 12 on the Moon in 1969, which had tested navigation techniques by landing within walking distance of an inert Surveyor probe. It is necessary for ERV and lander to touch down close to each other – and Pathfinder is as good a marker to aim for as any. There are other scientific objectives, such as in examining the behaviour of materials on Mars.

Just as reaching the Surveyor was a mission highlight for the Apollo astronauts, it is a cultural feat to visit the monument. A shot of mission commander Martha Ono cradling Pathfinder’s tiny Sojourner rover in her arms is the most forwarded post in social media history. Space archaeologists, however, howl with anguish.





Part Three  
The Decade  
of Earth

## THE SPACE HABITAT

2040  
—  
2049

**T**he largest single colony off planet Earth is in orbit. Lagrange Station is situated at L4 – the fourth Lagrange point – a gravitationally stable location in the Moon’s orbit around Earth.

The central habitat, a squat, tuna-can-like cylinder, is all but lost in a wider infrastructure of support facilities: a solar sail for station-keeping, an extensive radiator farm, and ring-shaped mirrors that provide the habitat with sunlight. The interior of Lagrange is spectacular, with a farmed landscape curving up over the visitor’s head. But this is a place of work, for 10,000 people. It was from here that the first crewed Mars missions were launched.

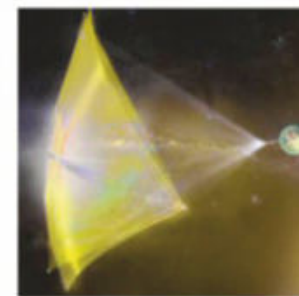
Now, though, Lagrange’s main customer is not Mars but Earth. Led by such prestigious bodies as the Cambridge University Centre for

Climate Management, founded in 2025, large-scale geoengineering initiatives are underway in an attempt to salvage Earth’s climate. Among them is ‘albedo manipulation’ – cooling the planet by reflecting or deflecting away some of the sunlight. By now, the tremendous orbital mirrors and lenses tended by Lagrange crews are themselves planetary in scale.

All this is controversial on Earth, because such solutions inevitably favour some nations over others. Amid rising sea levels, the desiccating tropics, and gathering migrant flows, there is a feeling of a slide to war.

However the citizens of Lagrange are more concerned about their own politics, rather than Earth’s. Here, on the Moon, and even on Mars, debates are underway on the future of human rights. A confined colony in space will always be an intrinsically tyrannous environment, because



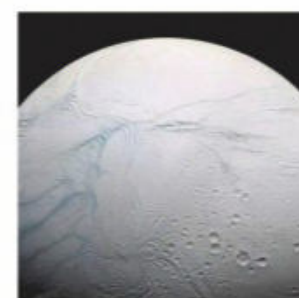


### THE SOLAR FOCUS

After decades of development, the Breakthrough Starshot programme achieves its first significant triumph.

The ultimate goal of Starshot is to send tiny 'light sail' craft to the stars. Such craft carry no propulsion system. Instead they are pushed by light from a tremendous laser on Earth.

The stars are still out of reach for Starshot – but in 2047, after a journey of 20 days, a trial craft reaches a significant interim goal: the 'solar focus', a point more than 500 times as far from the Sun as Earth, where the Sun's gravitational field, acting as a lens, focuses the light of distant stars and planets. And as it dashes through the focus, moving at a seventh the speed of light, Starshot picks up imagery from the star Fomalhaut, located 25 light-years away, with its known planet Dagon – and now, it is revealed, Dagon has a large moon, invisible without the lensing. A moon that shows traces of life.



### THE AI ASTRONAUT

Up to now, humans have been better than the machines at science in space. By the 2040s, though, AI is advancing rapidly. Now the designers believe

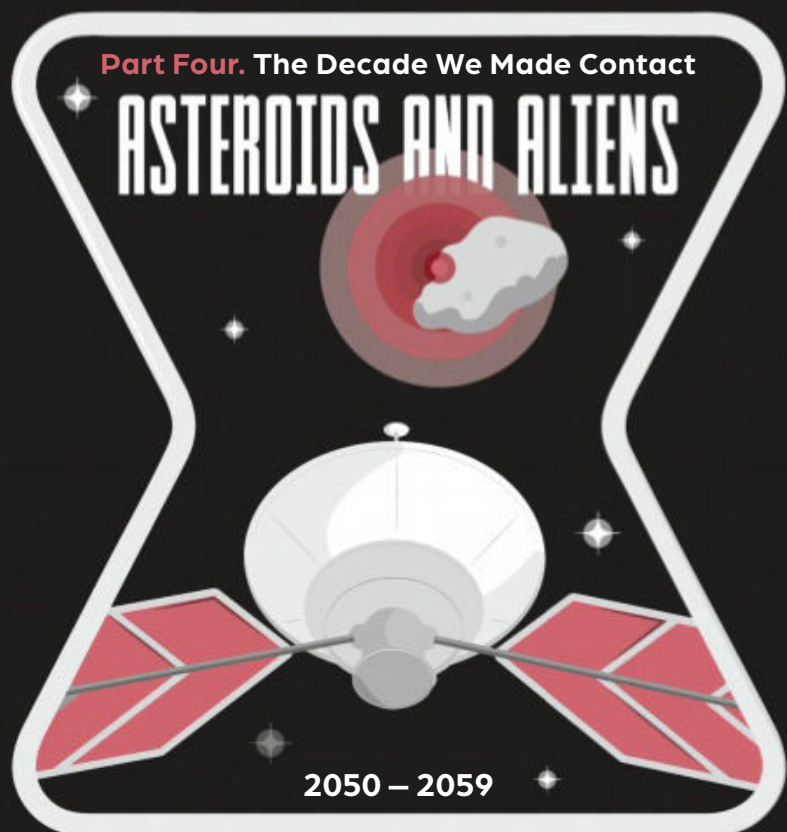
they are close to achieving an AI that is capable of exhibiting such human qualities as common sense, creativity and judgment.

This is demonstrated by ROBBIE, the ROBot Ice-moon Explorer, an advanced-AI mission to Enceladus, a moon of Jupiter. Far from following instructions from Earth, the probe devises its own research objectives, carries out its own explorations, and even designs and builds custom subprobes on the spot. An explosion of new science results follows – and all far more cheaply than a human mission. But some fear for the future of humans in space.

all human life will depend on centrally controlled systems. Bluntly, a tyrant in control of the air supply would have the power of life and death. A new constitution, called the Cockell Protocol, named after the astrobiologist Charles Cockell, is being drafted to ensure freedom and safety. It will be a new way of living, unimagined on the Earth – and yet, as many point out, with lessons for the inhabitants of that small world.

And on the Moon, at least, with the first children born there already in their teens, the right to freedom and self-governance is high on the agenda. This comes to a head in 2045, a century after the first use of atomic weapons in war. When the US attempts to set up a nuclear weapons site at its own Moon base, the lunar colonies – including the American ones – declare unilateral independence. A new nation is born, the first in space.





**T**he year 2051 marks the 250th anniversary of the discovery of dwarf planet Ceres, now known to be the largest object in the main asteroid belt between Mars and Jupiter. Some asteroids, known as near-Earth objects (NEOs), wander within the orbit of Mars, and even approach Earth. And the Trojan asteroids, beyond the main belt in Jupiter's orbit, are believed to have a mass several times more than those of the main belt itself.

And in the 2050s a new wave of super-smart automated probes push out through the Solar System, hunting the asteroids. One goal is science: the asteroids are thought to be relics of the Solar System's formation. Earth's safety is another factor. For decades we have been tracking NEOs; soon the probes will be able to push away any threats.

But what primarily draws the probes is the asteroids' promise.

Some asteroids are flying mountains of natural steel and precious metals. Others, known as C-type asteroids, are full of organic compounds and water. You can use asteroid dirt to make glass, fibreglass, ceramics, concrete, rocket fuel, and – with suitable engineering – all the requirements of life support.



But the probes' single most crucial task is to use asteroid resources to manufacture copies of themselves: to self-replicate. The plan is that a steadily growing swarm of probes will sweep out through the asteroids, at no additional cost to Earth. And the flow of materials to the inner Solar System will double in volume, then double again, and again...

Until one such probe, hunting down an anomalous heat source in the main belt, discovers something strange. An artefact, but not of human origin. It is a 'lurker', in the jargon. Alien, very ancient, it has been monitoring our Solar System for millions of years, and waiting for contact.

After much consideration and debate the miner cautiously approaches the stranger.

It is first contact: not between human and alien, but between robot emissaries.

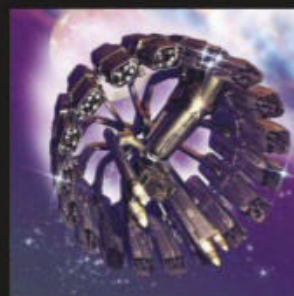




### **LURKERS**

The idea of using smart space probes as a means to make contact with extraterrestrial civilisations dates back to astronomer and physicist Ronald Bracewell, who proposed the idea in 1960. This was at the beginning of the SETI enterprise, which searched for signals from extraterrestrial intelligence using radio telescopes. Rather than transmitting brief

radio signals, Bracewell imagined sending out many cheap, long-lived probes equipped with artificial intelligence. A probe could sit in a target system and wait for a culture to develop, and then initiate contact. The advantages of this approach lie in the possibility of rapid dialogue with a nearby probe, compared to an interstellar exchange of radio signals which might last decades, as well as the probe's ability to wait for long periods for a contact opportunity.



### **SELF-REPLICATORS**

In 1980 physicist Frank Tipler used self-replication to develop Ronald Bracewell's lurker idea. The costs of an interstellar exploratory programme could be minimised if, rather than sending out lurkers to every star, the makers sent out a single probe capable of self-replicating. On arriving at a star system it would send out copies of itself to further

systems – and its descendants would do the same. Even if the colonising wavefront moved at a conservative 1 per cent of light speed, the Galaxy would be covered in 10,000,000 years: an immense period of time, but the Galaxy is perhaps a thousand times older. There has been time for the makers of the asteroid-belt lurker to seed all the stars with their probes.

Deep in the asteroid belt, the AI miners understand this. And they begin to consider the opportunities and hazards of unrestricted growth.





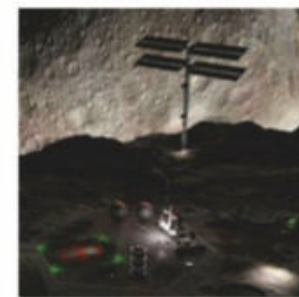
**I**n the 2060s, the 100th anniversary of the Apollo 11 landing approaches. And a grand new project is underway to connect Earth to sky. The Borneo Tower is a space elevator. It began with a satellite orbiting the Earth in 24 hours at an altitude of 36,000km. It was placed in a geosynchronous orbit, which means it hovers over the same spot on the equator, the chosen site being Borneo. Then, a cable of super-strong materials was dropped down to the surface, to be used as the basis of an elevator system, carrying goods and people from Earth to space and back again. The reduction in cost

of getting cargo into space is huge, but the engineering details are challenging. The key breakthrough was the successful development of ‘super-fullerenes’, carbon molecules that offer cables with high tensile strengths. On Mars, building such an elevator would be easier because of the planet’s lower gravity. The Olympus Elevator is already on the drawing board.

Resources from space are brought down the space elevator in increasing volumes, safely and cleanly, to help the recovery of Earth’s environment – and, eventually, the preservation of Mars’s.

Meanwhile, the development of an automated industrial civilisation in deep space continues. With self-replication and AI technologies rapidly advancing, a new generation of probes – themselves built by earlier probes – is pushing further out: to the ice giants, into the Kuiper Belt beyond Pluto, and soon





### GROWTH LIMITS

While resources pour from the sky to Earth, the AIs in deep space are increasingly aware of the exponential growth in the volumes of

resources humanity has had them extract. Already, the main belt miners are returning 2,000,000 tonnes of iron ore per year, matching Earth's own output. But the industry could double in volume in another 20 years – and double again 20 years after that. The main belt contains some billion billion tonnes of ore, but that could be consumed in a mere eight centuries, if the doubling process continues.

The AIs are aware of the damage done to Earth in the past by unrestricted, exponentially growing exploitation. The AIs, their wisdom developing, fear for the long-term integrity of the Solar System, for the impact on life yet to be discovered, as well as the effect on humans when the inevitable crash comes. So they suggest the 'Milligan Accord'. This is a 'one-eighth' rule, meaning exploitation of any resource should stop when one-eighth of it has been consumed, a safe three doubling intervals before exhaustion. This would preserve most of the Solar System as 'wilderness'.

On a slowly recovering Earth, humanity accepts the advice of its junior partners.



### FOMALHAUT

Thanks to painstaking analysis, the home star of the alien lurker probe has been identified as Fomalhaut, 25 light-years away, with the apparently

life-bearing moon of Dagon probably its origin. Already, a Starshot probe has been sent to the moon – but will not arrive before 150 years have passed.

However, it is soon realised that the light of the Starshot laser launcher itself will have been visible, after just 25 years, as a brilliant star in the skies of the Dagon moon. Perhaps the inhabitants will choose to reply in a similar manner. In which case we may receive our first calls from extraterrestrials by laser beams travelling at the speed of light. And the first reply may come in a mere 50 more years – in the year 2119. **SF**

even the Oort Cloud with its enigmatic Planet Nine. The flow of science results and industrial development is spectacular. But this is all happening independently of humanity.

There are now healthy democracies on the Moon and Mars, and in Lagrange and other large orbital habitats. But it has become obvious that humans have no direct role to play in space beyond the orbit of Mars, and none venture there. And indeed humanity has, gracefully, agreed with the AIs what is known as the Milligan Accord, to accept a long-term limit on the industrial development of the Solar System. The quality of judgment in the new generations of AIs is vindicated.

But many eyes look to the sky – a Starshot probe has been sent to Fomalhaut, the origin star of the alien lurker. Soon, perhaps, humanity's relationship with the cosmos will change again.

by **STEPHEN BAXTER**

*Stephen is a science fiction author, who has written more than 40 books.*



# WELCOME TO THE NOVACENE

## WHAT IS THE NOVACENE?

It's the name I've given to the new age of intelligent beings. Hollywood has filled our minds with robots and mechanical devices that follow on from humans and take over the planet. This seems to me absolute nonsense. These new beings will arise, like us, from Darwinian evolution, and they will need us to regulate the climate. This could be one of the most crucial periods in the history of the planet and perhaps even of the cosmos.

## TELL ME MORE ABOUT THESE BEINGS.

They will be biological entities – I use the term 'cyborg'. But they will no longer use neurons [the nerve cells that carry signals in the brain], because these are incredibly slow and inefficient – signals along neurons travel about 10,000 times slower than they do along copper wire. We'll be able to use our cleverness to assist the whole process – that's how there will be a switch from using neurons. There is no natural source on Earth of the special components [that will be needed for the cyborgs], like ultrafine wires made of pure unbroken metal. So there are things that will be changed deliberately, but it's still evolution. Like it or not, the emergence of cyborgs cannot be envisaged without us humans playing a god-like – or parent-like – role.

So we will start to produce a more efficient communication system for our brains. The Novacene will be inhabited by cyborgs who think and act roughly 10,000 times faster than we or other animals do. That's about the same speed difference as we are from plants.

ON THE EVE OF HIS 100TH BIRTHDAY, CREATOR OF GAIA THEORY **JAMES LOVELOCK** HAS COME UP WITH HIS MOST VISIONARY IDEA YET. HE TELLS **JAMES LLOYD** ABOUT THE COMING AGE OF HYPER-INTELLIGENT BEINGS

## SO THEY'LL LOOK AT US LIKE PLANTS?

Yes, and this is an important concept, because plants are desirable things. We like them. We have all kinds of relationships with plants, and I see no reason why the Novacene organisms should not have a similar range of relationships with the organisms that are around today. It's a new kingdom of nature, if you like.

Somebody said to me, 'How could you possibly be interested in a life form that's a 10,000th of the speed you are?' I mean, it's so snail-like.' And I thought, 'Why do you go to Kew Gardens, then?'

## WHEN WILL THE NOVACENE BEGIN?

It already *has* begun. What's been happening recently with AlphaGo is an evolutionary step in this direction [in 2015, Google DeepMind's AlphaGo became the first computer program to beat a professional human player at Go – a Chinese board game that's more complex and difficult to master than chess]. AlphaGo combined human input with the machine's ability to teach itself. This was an enormous step forward, but an even bigger one followed. In 2017, DeepMind announced two successors: AlphaGo Zero and AlphaZero, neither of which used human input.

The new life of the Novacene will go far beyond AlphaZero's autonomy. It will be able to improve and replicate itself. The simplest way of looking at Darwinian evolution is that the organism that leaves the most progeny is the one that succeeds, and that rule applies to all realms. I think it will apply in this case, too. ●

**"THE NOVACENE WILL BE INHABITED BY CYBORGS WHO THINK AND ACT ROUGHLY 10,000 TIMES FASTER THAN WE OR OTHER ANIMALS DO"**







### WHEN WILL WE SEE THESE HYPER-INTELLIGENT BEINGS LIVING AMONG US?

That's very difficult to predict. The speed of evolution is slow and comprehensible right now, but once it starts moving and becomes hyper-intelligent in its own context, it might be exceedingly fast. We're talking an increase of millions, in terms of acceleration.

### AND WHAT WILL THEY LOOK LIKE?

I've kind of thought of them – if I do think of them at all – as almost ephemeral. Sort of floating entities. Very lightweight. Perhaps even transparent. So, that's my particular vision. Others will see them differently. We don't look terribly like some of our ancestors, so why should they?

### YOU MENTIONED EARLIER THAT THESE CYBORGS WILL NEED US. WHY IS THAT?

If I'm right about Gaia theory, then the sustenance of the planet will require continuous cooperation of the various kingdoms. I mean, the plant kingdom cannot be suddenly removed – it's got to be there because something's got to fix the solar photons coming in and turn them into energy and food.

The kind of function that we're fulfilling [as humans] is more on the intelligence level than the metabolic level, but it will have to go on. In their own interests, the cyborgs will be obliged to join us in the project to keep the planet cool.

I'm not against Hollywood. It's a wonderful source of entertainment, but it does tend to be over-aggressive and fighting battles all the time. I don't see that there's any need for that with our relationship with the cyborgs.

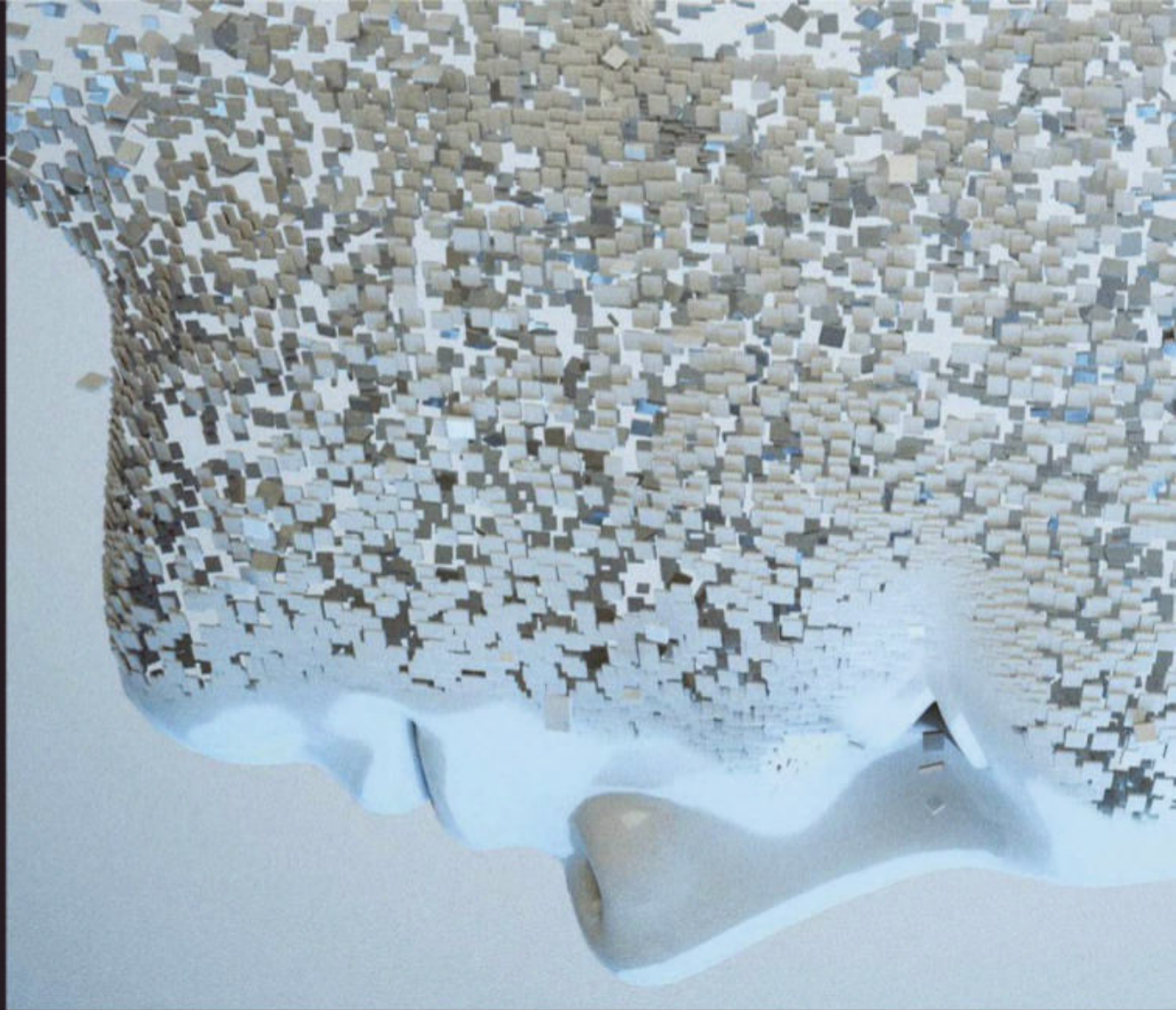
### YOU JUST MENTIONED GAIA THEORY, WHICH YOU ARE KNOWN FOR CREATING. HOW WOULD YOU EXPLAIN IT TO SOMEONE WHO'S NOT COME ACROSS IT BEFORE?

It sees the Earth as a system made up of all the rocks, all the atmosphere, all the ocean, and all the living things, and these interact together to sustain a state that keeps the living part of it surviving.

It has to. If the living part dies, then so does the whole darned system, and it goes back to becoming a [dead] rocky planet like the ones that we have [in the Solar System] already.

### AND SO THE NOVACENE BEINGS WILL NEED US TO HELP REGULATE THE SYSTEM, BECAUSE WE'RE SUCH AN INTEGRAL PART OF IT?

Exactly, yes. One would imagine that they would



**"I'VE KIND OF THOUGHT OF THEM – IF I DO THINK OF THEM AT ALL – AS ALMOST EPHEMERAL. SORT OF FLOATING ENTITIES"**

want to keep the status quo here for a fair time. They might eventually find means of moving to somewhere more comfortable, but there isn't anywhere in the Solar System where one could conceive that would be better than the Earth. Mars certainly wouldn't be.

And we will need these cyborgs, too. We'll need them very badly.

### WHY'S THAT?

The greatest threat to life on Earth is overheating. We're obviously playing a huge part now with climate change. But the long-term threat to life is the exponentially increasing output of heat from the Sun ['main sequence' stars such as the Sun gradually become hotter and brighter as they age]. In a relatively short time – several hundred million years – its heat output will be more than we can take.

Unless, of course, the Novacene characters put up reflective mirrors or something like that [to reduce the amount of sunlight reaching the Earth]. Geoengineering projects will be well within their capability. It's conceivable that we could do it ourselves, but in the Novacene there



## DISCOVER MORE

James Lovelock's new book *Novacene: The Coming Age Of Hyperintelligence* (£14.99, Allen Lane) is out now.



### ON THE PODCAST

To listen to more of the interview, including James Lovelock's reflections on his life and career, visit [sciencefocus.com/science-focus-podcast](http://sciencefocus.com/science-focus-podcast)

that we've appeared. It involved a lot of luck – the Earth's location near the Sun, the impact of a Mars-like object which changed our planet's properties [this is currently the leading explanation for the formation of the Moon]. All sorts of things like that. Our cosmos is simply not old enough for the staggeringly improbable chain of events required to produce intelligent life to have occurred more than once.

### IF WE ARE ALONE, WOULD IT MAKE US SPECIAL?

Well, one idea is that the truly fundamental property of the cosmos is the bit [the basic unit of information]. And that the cosmos is slowly moving towards an assembly of bits.

### SO THIS WOULD BE A MOVEMENT OF INFORMATION AND INTELLIGENCE OUT FROM THE EARTH INTO THE COSMOS?

Yes. The Novacene will be a movement in that direction.

### WOULD THIS GIVE HUMANS A SENSE OF MEANING THEN – IF WE'RE THE SOURCE OF THIS INTELLIGENCE?

I think it's sheer hubris to think about your sense of meaning. Life is something to be enjoyed, and if you don't enjoy it, you're doing it wrong.

### HOW DO YOU FEEL ABOUT THE FUTURE OF OUR PLANET?

I'm a bit worried. I've got a lot of grandchildren, and great-grandchildren come to that. Yes, I think it could be very dodgy in the intervening periods.

### YOU MENTIONED EARLIER THAT YOU DON'T THINK MARS WOULD MAKE A GOOD ALTERNATIVE HOME...

It's absolutely crazy. I mean, we've got a beautiful planet here. Absolutely beautiful. And with far less effort, we could treat it better and make it desirable to live in. Whereas it would involve a monumental effort to shift stuff to Mars and make it fit for life. If you ever could.

We now know more about the surface of Mars than we do about the bottom of the ocean. And if we're concerned about the climate of the Earth and its future, it's much more important to know about our ocean.

### YOU'RE SET TO TURN 100. LOOKING BACK AT YOUR CAREER, WHAT DO YOU HOPE YOUR LEGACY WILL BE?

Legacy? There's more work to do. I've got another book to write! **SF**

will be cooperation right across the system of life on Earth, as there is now.

### YOU SAY IN YOUR BOOK THAT YOU DON'T THINK INTELLIGENT LIFE EXISTS ELSEWHERE IN THE COSMOS. WHY IS THIS?

Well, if the conclusions drawn about the age of the cosmos [13.8 billion years] are more or less correct, then there hasn't been time for anything else. It took the process of evolution 3.7 billion years – almost a third of the age of the cosmos – to evolve an understanding organism from the first primitive life forms. It's quite remarkable

**ABOVE:** Novacene beings could help us install giant mirrors over Earth to reduce the amount of sunlight reaching us, therefore preventing the planet from overheating







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Your donation will support UNHCR's emergency work in Yemen and where refugees and internally displaced people are in need.



COMMENT

# GUT FEELINGS

Listen carefully, the gurgles of a grumbling belly could be a cry for help

One of my medical heroes is Prof Barry Marshall of the University of Western Australia. We met in the 1990s when I made a documentary about him and his colleague, Robin Warren. I created the film, *Ulcer Wars*, because they had a great story to tell: they had identified and grown a species of bacteria they called *Helicobacter pylori* and had become convinced that it was responsible for the majority of cases of gastric cancer and gastric ulcers.

As a film-maker, it appealed to me that in the 1980s Barry had drank from a beaker containing *H. pylori*. He became ill and a biopsy of his gut revealed that the *H. pylori* had indeed begun colonising his stomach lining and the upper part of his small intestine, causing inflammation, or gastritis. He took antibiotics, his symptoms improved and biopsies confirmed the *H. pylori* had gone.

When I made *Ulcer Wars* there was widespread scepticism about their claims about *H. pylori*. That changed when the pair won the Nobel Prize in Physiology or Medicine in 2005. It was thanks to Barry's example that I embraced my policy of on-screen self-experimentation.

I caught up with Barry recently and he showed me his latest project, which may again change our understanding of a common gut problem. His team is investigating irritable bowel syndrome (IBS). IBS is incredibly common, affecting about 10 per cent of the world's population.

✕ **“We’re using sensing technology originally created to track the munching sounds of termites”**

Symptoms include pain, bloating, diarrhoea and constipation. There is no simple, reliable test and many people either go undiagnosed or are dismissed as overly anxious.

So there is a lot of interest in a test that Barry's team is developing. It uses a belt that is strapped to a patient's stomach, encasing a small, sensitive microphone. The research is called the Noisy Guts Project.

“We wanted to find a way to listen to the rumblings and grumbings of the gut, to identify patterns that characterise chronic gut conditions

like IBS,” Barry says. “We’re using acoustic sensing technology that was originally created to track the munching sounds of termites.”

They recruited volunteers, some with a diagnosis of IBS, others with healthy digestive systems, and asked them to wear the belt and have their gut sounds recorded for two hours post-fasting, and then for 40 minutes after a standardised meal.

Their gut sounds were uploaded into a computer that used machine-learning to identify differences between healthy and unhealthy guts. They then tested their system on a similar range of people, this time mixed up so the researchers didn't know their medical histories.

The system worked well, accurately detecting IBS 87 per cent of the time, with few false positives. The team is now testing the system with large numbers of patients before bringing it to market. **SF**



**MICHAEL MOSLEY**

Michael is a writer and broadcaster, who presents *Trust Me, I'm A Doctor*. His latest book is *The Fast 800* (£8.99, Short Books).





## COMMENT

## DIGITAL VS ANALOGUE

How tech has transformed the creative process

**T**he last time I wrote something linearly – as in, started at point A and ended, unedited, at point Z – was in 2004. The timer had started in an essay exam for my master's degree, and on the desk in front of me was a single blank page. I had to answer the question on the board using only a pen. I hadn't written anything of substance without a keyboard and mouse in more than a decade, and something fundamental had changed. My brain now organised itself in disorganised snippets of phrases and paragraphs that were entirely out of place until they were cut and pasted into their correct order. But that's not how pens work.

The essay I submitted was covered in circles and arrows and scribbles in the margin that begged the examiner to read paragraph three before paragraph one, and to swap out this phrase with another. I can only assume they were in the same boat as me, because somehow I passed.

In the 100th episode of *Digital Human* – 15 years of even more entrenched computer use later – we poked at this mental shift. We decided to make the programme using old skool, non-digital methods: heavy recording machines, limited tape supplies, no copy-and-paste feature, and certainly no 'undo'.

This is entirely different from how we've been making programmes for the 20 years since digital editing



**“The constraints of the analogue world are foreign to how we create things today”**

tools arrived at the BBC. Nowadays, we don't use razor blades to cut single-use snippets of magnetic tape. Nor do we use sticky tape to paste it into place. We select things with a mouse, occasionally copy the selection so we have another version of it, and paste it elsewhere. We add music underneath, and shift it around at will. None of this is done live – not even my links. Those are recorded separately and slotted in.

In the 100th-episode experiment, everything had to have human hands on it, and every touch degraded the original. Everything had to be done 'as live' – from fading up the music to reading my lines into the story. It all had to be meticulously planned from the moment the idea came up,

because it had to be recorded in one go. It was thrilling, but exhausting in an entirely different way from our regular process because of the analogue constraints.

The digital age doesn't alleviate cognitive heavy lifting, though; it simply pushes it to the end of the process. But the ability to copy in high fidelity and endlessly undo means that we are never entirely done. We can forever edit out a contributor's ums and ahs, we can shift things around. We now have an unlimited toolset in drop-down menus, so we can add fades and filters until the end of time.

I didn't write this column on paper with a pen, but I wish I had because I've been cutting and pasting it for a week. The constraints on creativity that the analogue world enforces are now quite foreign to how we produce things. Putting the cognitive load at the front end is an entirely valuable, if retro, way to create. And it's something that, combined with the endless toolbox we now have at our fingertips, is powerful indeed. **SF**



**ALEKS KROTOSKI**

Aleks is a social psychologist, broadcaster and journalist. She presents *Digital Human*.





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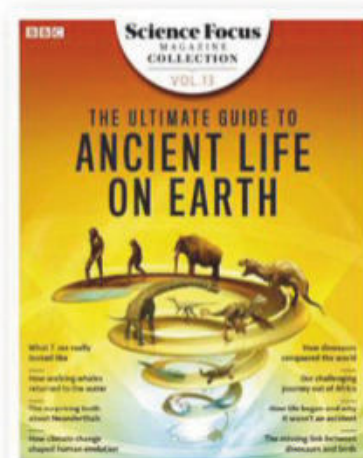
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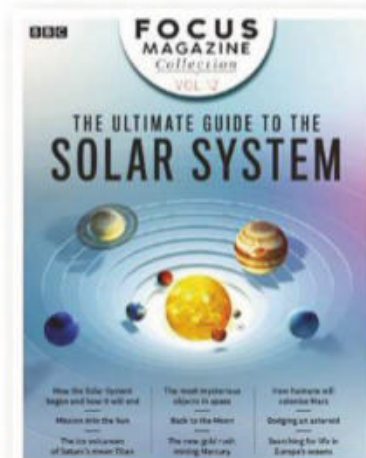
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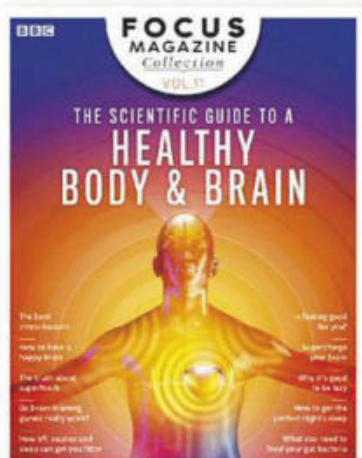
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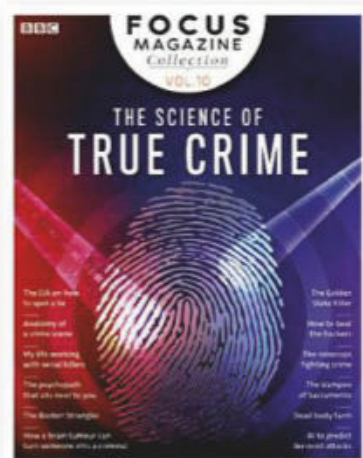
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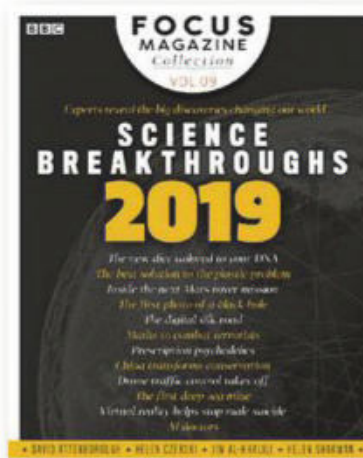
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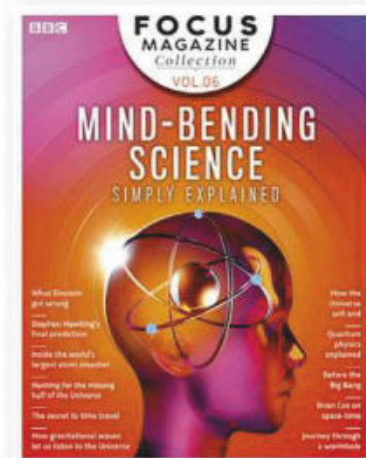
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# HOW TO ARGUE WITH A MOON LANDING DENIER

One in six Brits believes that the Apollo 11 landing was a hoax. Our guide can help you debunk their arguments...

WORDS: PAUL PARSONS

**O**n 20 July 1969, the Apollo 11 Lunar Module landed on the Moon. The highlight of the mission was a 2.5-hour moonwalk, during which Neil Armstrong and Buzz Aldrin gathered soil and rock samples, planted a US flag, and basked in the glory of becoming the first human beings to set foot on another world. Five more crewed landings would follow over the next three years.

These were astonishing feats. Indeed, some folk find them all *too* astonishing. A recent YouGov poll found that 16 per cent of British people still cling to the conspiracy theory that the Moon landings were staged. It's an idea that's been around since the mid-1970s, with various reasons suggested for why the US government would want to orchestrate a hoax, from a need to win the Space Race, to a way of distracting the public from the Vietnam War.

Moon landing conspiracy theorists have come up with a number of pieces of 'evidence' for their beliefs. So we've decided to debunk them one by one. ➤

NASA/SC





# “THERE ARE NO STARS IN ANY OF THE PHOTOS”

If you believe the conspiracists on this one, then it was too complicated for NASA to get all the stars in the right place, so they left them out. Yes, you read that right.

Perhaps it's easy to forget that even astronauts – gifted though they may be – still require light in order to see what they're doing. That's why all the Apollo moonwalks took place during the lunar day, in full Sun. The cameras were therefore set on short 'daytime' exposures (otherwise everything would have appeared dazzlingly bright). And these settings were not sensitive enough to pick up any stars.

“Show me a photo of a night football game under lights below an open sky, and point to any visible stars,” says spaceflight historian and analyst James Oberg.



# “INCONSISTENT SHADOWS PROVE THAT ARTIFICIAL LIGHTS WERE USED”



## “THE FOOTPRINTS ARE TOO WELL-PRESERVED”

If you go to the beach and walk in dry sand, your footprint collapses immediately. To leave a good print, you need to walk where it's wet. But wait – there's no moisture on the Moon.

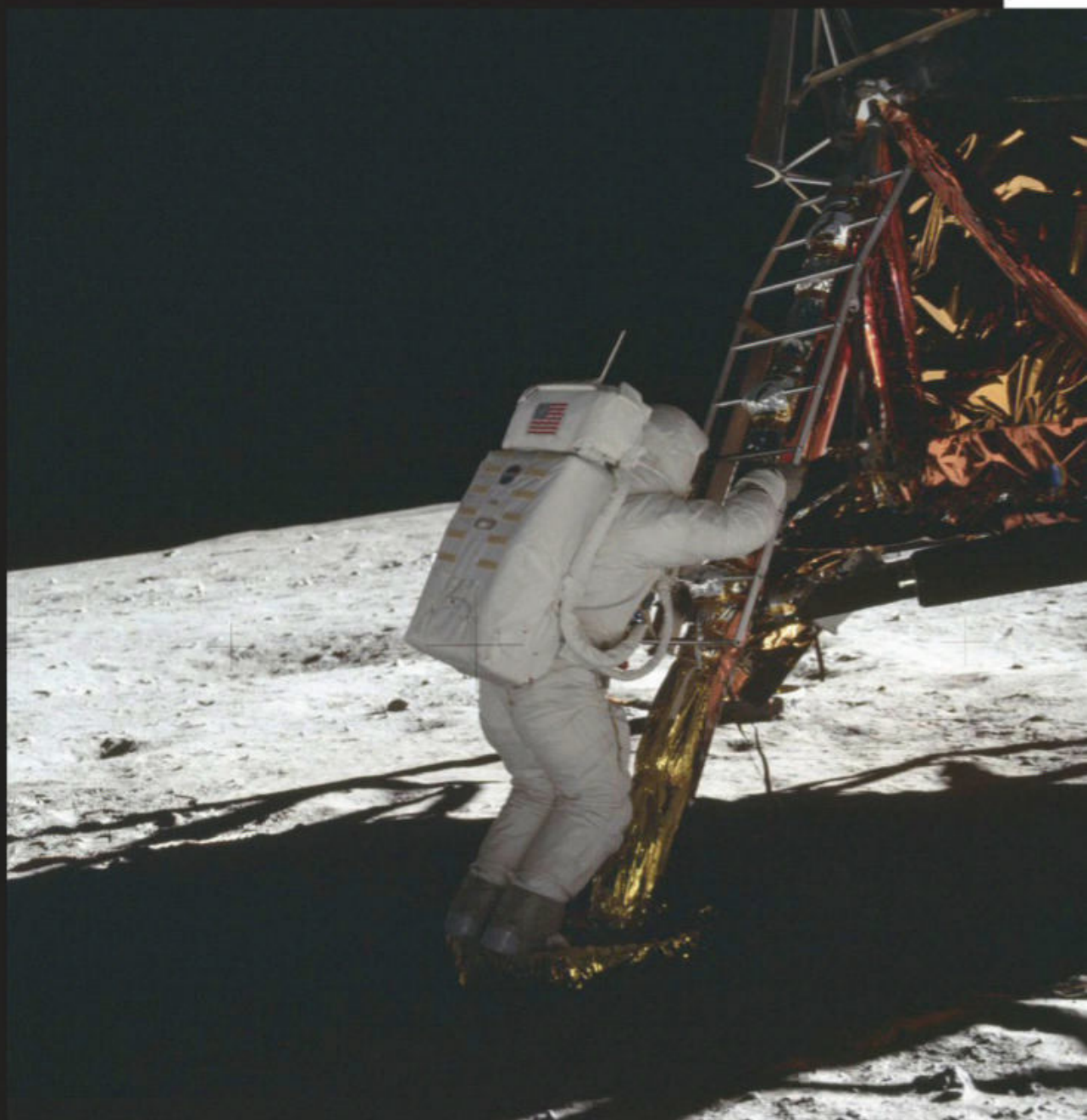
In fact, lunar dust is different from sand. Grains of sand have been weathered by the seawater and the atmosphere to give them a rounded shape. So getting them to hold together is like trying to stack a pile of ping-pong balls.

“The dust on the Moon is actually ground-up rock, and under a microscope you can see it's extremely sharp and rough, like volcanic ash,” says Dr Phil Plait, an astronomer and creator of the *Bad Astronomy* blog. “This acts like little hooks holding it together, so it keeps a print.” And as there's no wind on the Moon, the prints will stay there for millions of years.

Some Apollo images reveal shadows on the Moon that are not parallel, leading conspiracy theorists to declare that the scenes must have been lit from multiple angles, like in a studio.

Uneven surface topography explains many of these cases, where subtle slopes dramatically alter the apparent orientation of shadows falling on them. Others are due to perspective – the geometrical effect that makes parallel lines appear to converge on a distant vanishing point.

One image in particular has been seized on by the truther brigade, showing Aldrin standing in the shadow of the Lunar Module, yet brightly illuminated. Studio lights? Alas, not. The lunar surface reflects sunlight – a fact evident to anyone who's been out after dark on a full Moon. So even though Aldrin is in shadow, the glow of the surrounding terrain, reflecting off his white spacesuit, makes him visible.





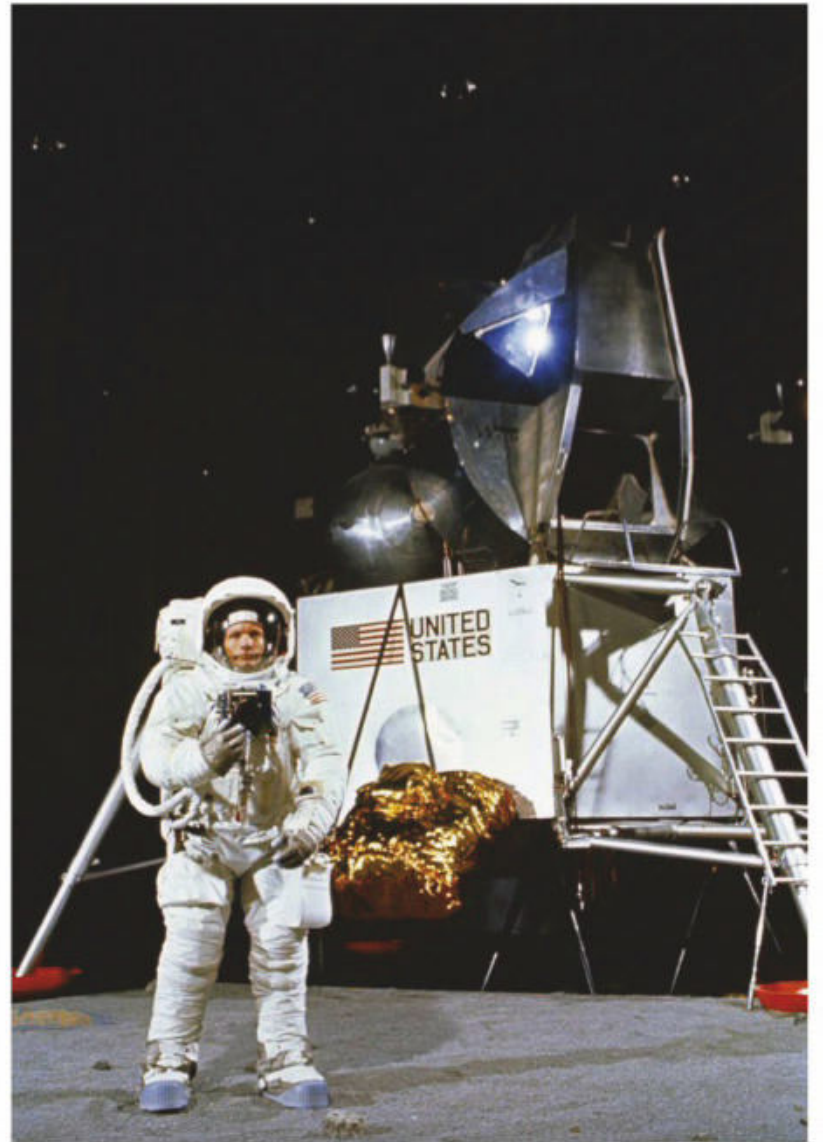
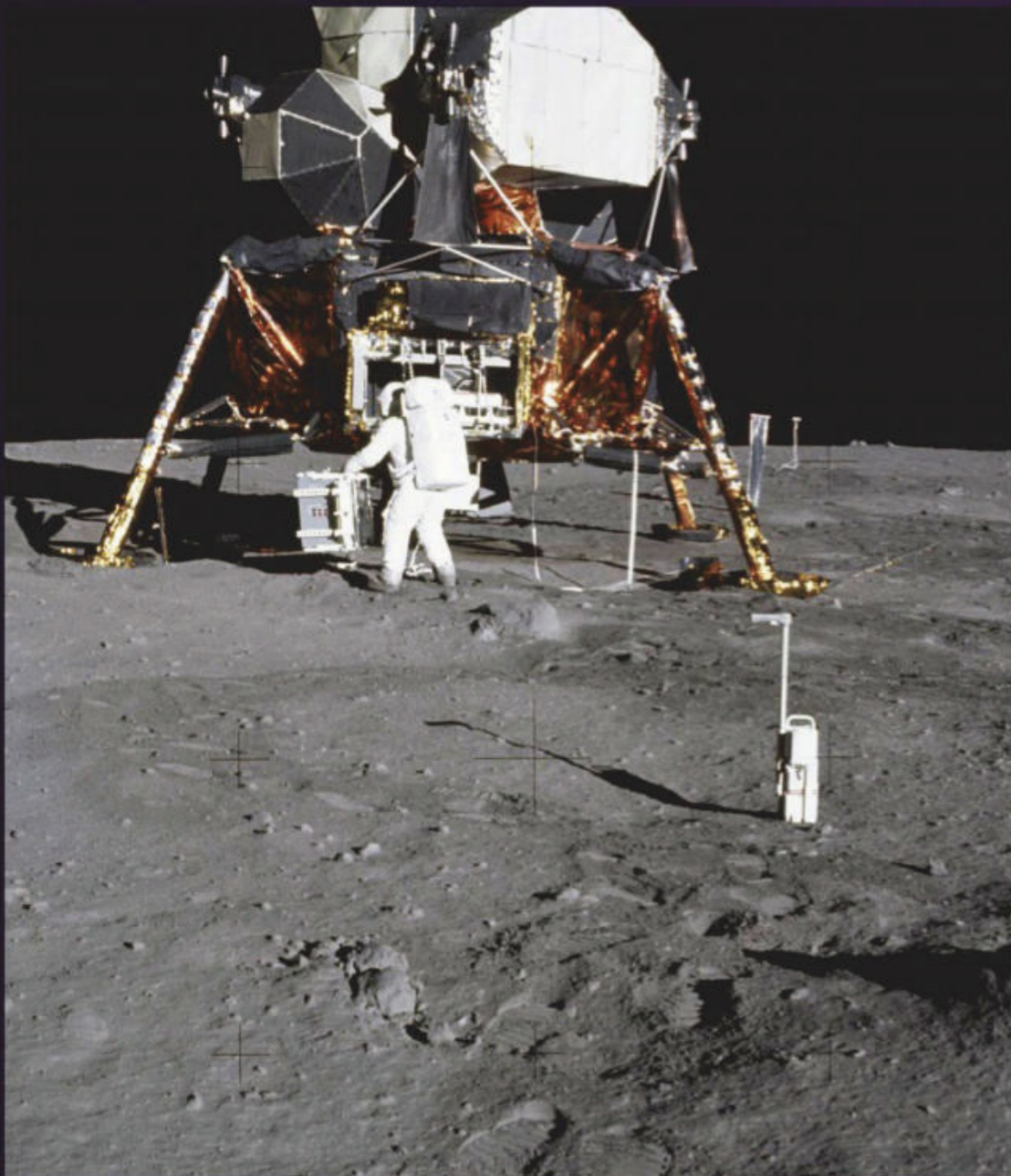
# “THE LUNAR MODULE MADE NO CRATER OR DUST CLOUD WHEN IT LANDED”

The Lunar Module did actually kick up a large amount of dust in the final moments before touchdown.

“Buzz Aldrin even comments on it during the Apollo 11 landing, and you can see it in the descent footage,” says Plait. But with no atmosphere to hold the dust in suspension, it fell straight back to the lunar surface – hence no cloud.

There’s also no blast crater because, in a vacuum, the normally narrow exhaust jet from a rocket engine quickly fans out into a wide cone shape. This causes the pressure in the exhaust to drop, greatly reducing its impact on the ground below.

The Lunar Module used a single rocket engine to slow its descent to around one metre per second (walking speed), before gently touching down on the Moon’s surface.



# “THE WHOLE THING WAS FILMED INSIDE A STUDIO SET”

Some Moon landing deniers claim that bungee harnesses or slow-motion photography were used to make it look as if the astronauts were moving in the low gravity of the Moon. Some have even gone so far as to suggest that Stanley Kubrick directed it.

Alas, while entertaining, these ideas have since been put to the test – most prominently by the TV show *MythBusters* – and roundly debunked.

“If the astronauts had been filmed in slow-mo, then their arm movements would have been slowed as well, but you can see in the video they’re not,” says Plait.

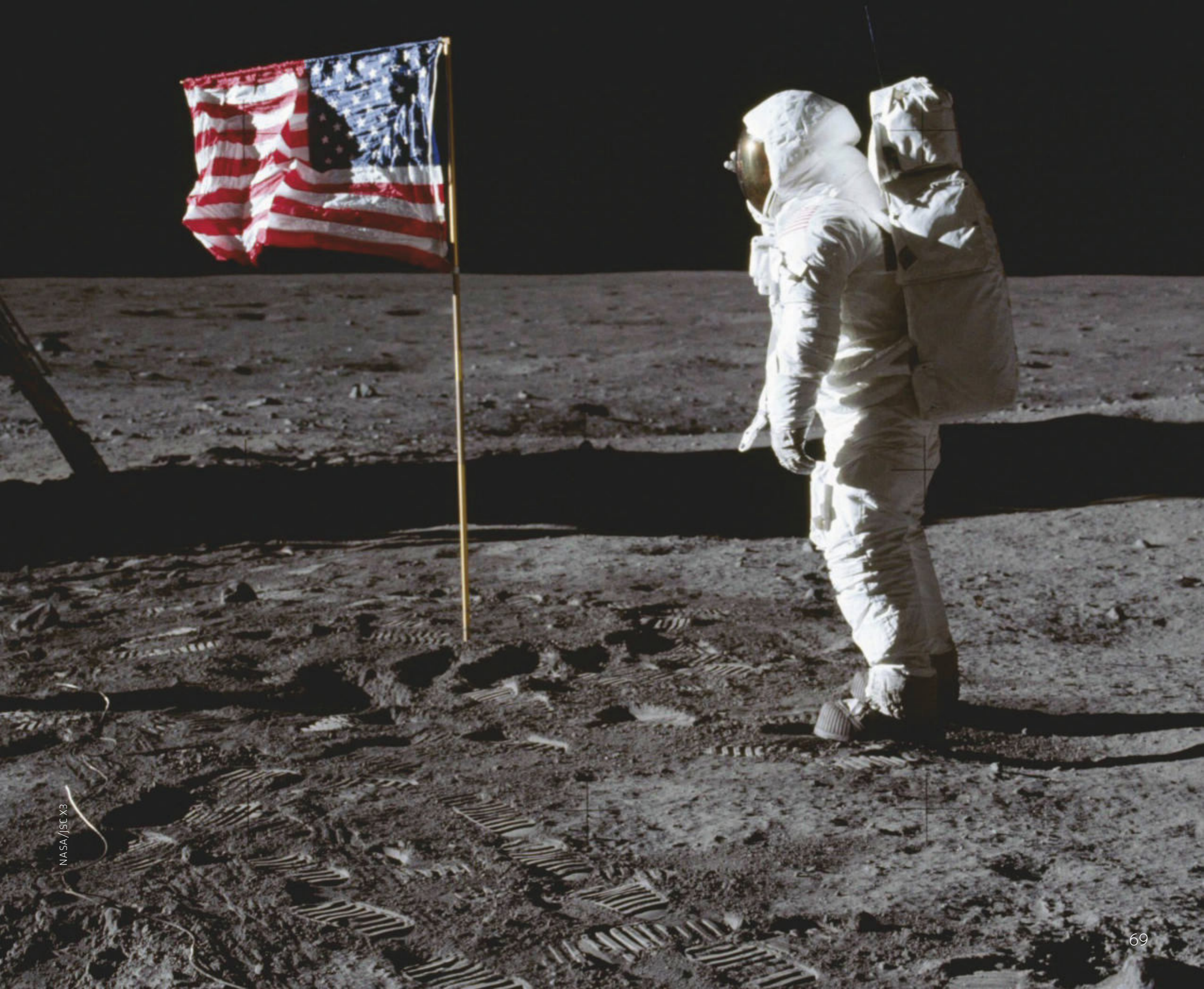
Similarly, tests on Earth with bouncing astronauts in bungee harnesses show that parts of the spacesuit not directly attached to the harness, such as the helmet assembly, waggle around much faster in our planet’s gravity than they would in the feeble gravity of the Moon – and much faster than they do in the Apollo footage. In the image above, which is perhaps the origin of the theory, Neil Armstrong is undergoing training at NASA.



# “THE AMERICAN FLAG WAS FLAPPING, BUT THERE’S NO WIND ON THE MOON”

First things first – the flag was not flapping! It’s correct that there’s no wind on the Moon (and indeed no atmosphere), which is why the nylon flag was mounted using not just a pole but also a horizontal bar, so that it didn’t unceremoniously droop. “Any object hanging from a bar will swing back and forth a long time after

being bumped, as the flag was, by an astronaut,” says Oberg. On Earth, the swinging would die away quickly because of air resistance. But in the lunar vacuum it persisted, giving the illusion of a breeze. Other than this, the flag was eerily immobile, even holding its crumpled shape in the Moon’s low gravity.



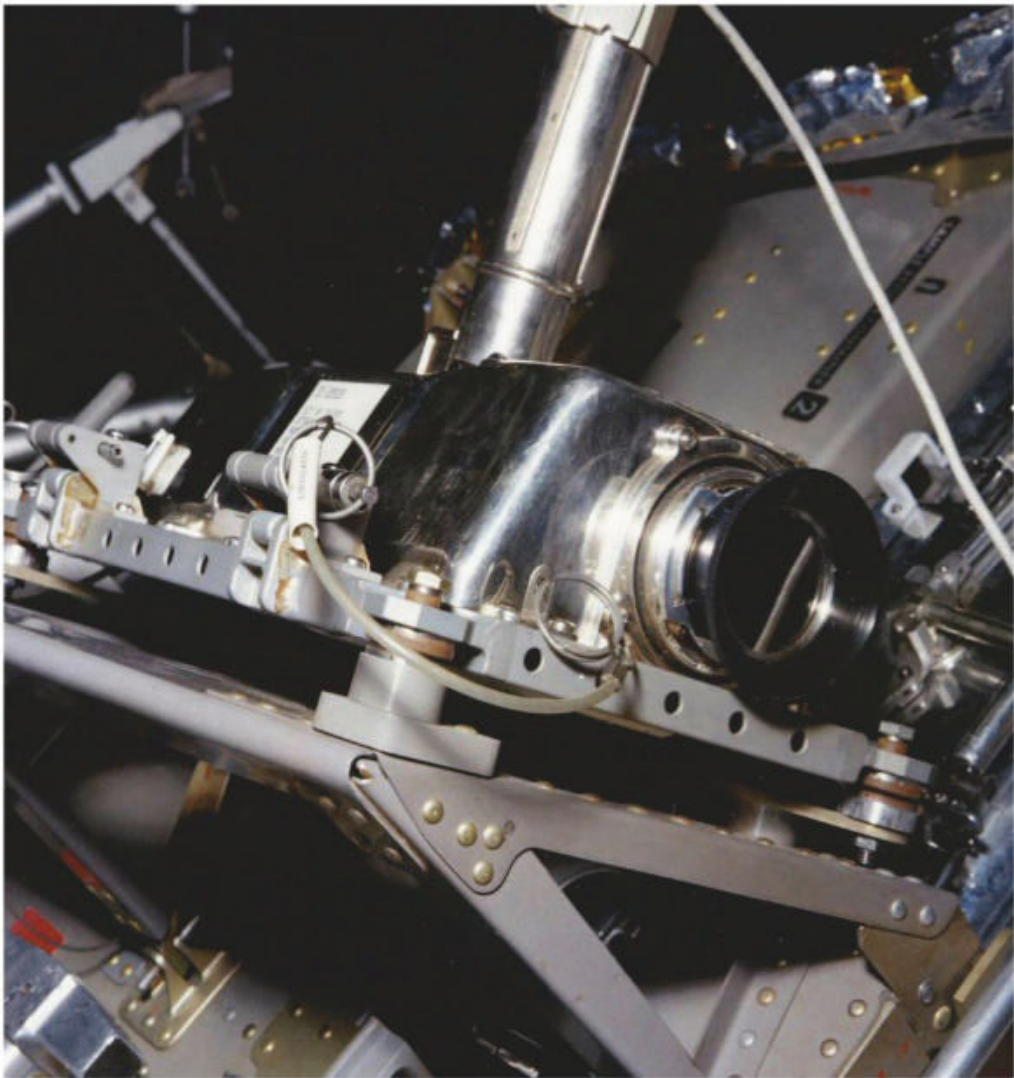
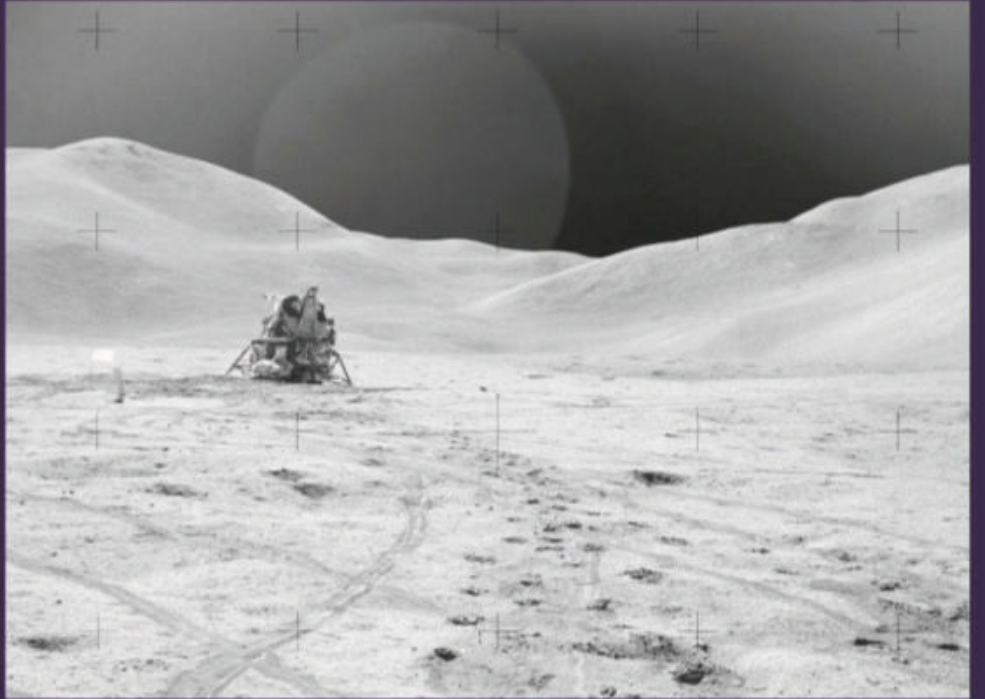


# “WHO WAS FILMING NEIL ARMSTRONG STEPPING ONTO THE MOON?”

That’s probably the easiest to answer of all. The Lunar Module was equipped with a black-and-white television camera, externally mounted and trained on the descent ladder.

The camera was stowed during the descent with other equipment behind a panel on the outside of the Lunar Module. Just before his moonwalk, Armstrong pulled a cord, allowing the panel to drop down, while Aldrin switched the camera on from inside.

This enabled an estimated 600 million people around the world to watch as Armstrong climbed down the ladder and uttered those now famous words: “That’s one small step for [a] man, one giant leap for mankind.”



## “THERE ARE IDENTICAL BACKGROUNDS IN SOME OF THE PHOTOS. A PAINTED BACKDROP WAS USED”

It’s correct that some of the backgrounds are identical – but this doesn’t imply by any stretch that a painted backdrop was used. It’s just a perspective effect that happens when the background is very far away.

“This is exactly the same thing you see when you’re driving and nearby trees whizz by, but the distant mountains move slowly,” says Plait. “Two photos taken a few yards apart will show different foregrounds, but the background hardly moves at all.”

We don’t immediately register this effect in Apollo photos, possibly because the abstract shape of the Moon’s features means that a distant mountain looks much the same as a nearby hill, making it easy to think the background’s much nearer than it actually is. The true lie of the lunar land has since been confirmed by orbital mapping.



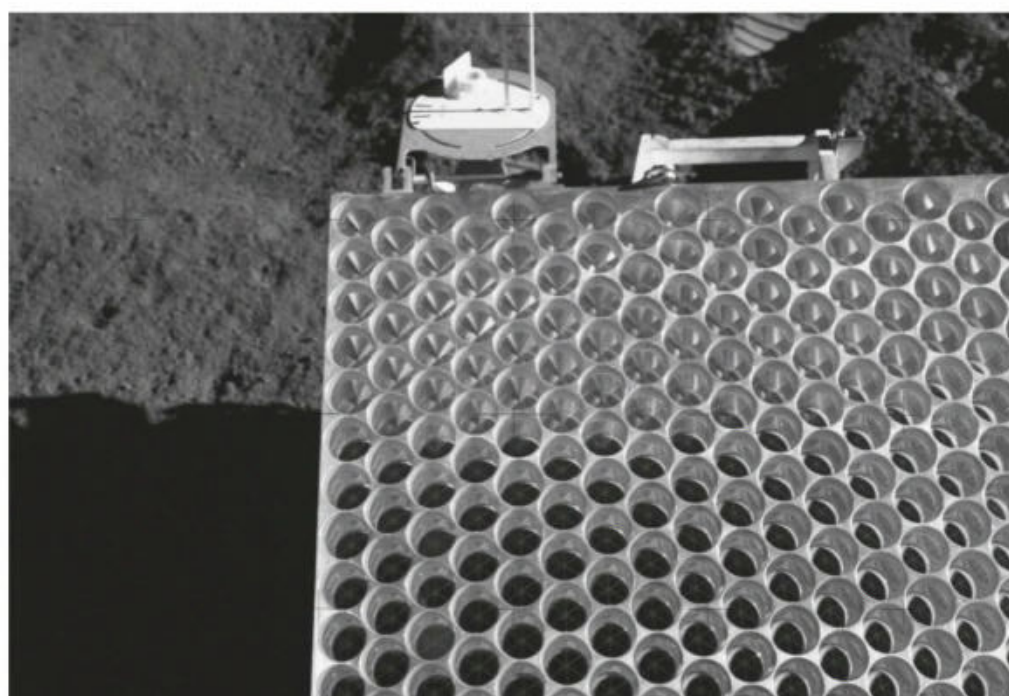
## AND ANOTHER THING...

If you're still not convinced, here are five more explanations to put the nail in the coffin of the Apollo conspiracy theories



### WHISTLE-BLOWERS (OR LACK THEREOF)

The Apollo program was a truly mammoth undertaking, combining the efforts of more than 400,000 individuals, and thousands of private companies. Maintaining secrecy would have meant each and every one of these people keeping schtum during the 11 years that the project ran, and for the 50 years that have elapsed since. Sound reasonable?



### RETROREFLECTORS

Each Apollo lander left a 'retroreflector' on the lunar surface – a mirrored device to bounce back light to its source. Anyone with a powerful enough laser can aim it at one of these reflectors and, in principle, measure the light travel time to the Moon and back, revealing its distance – and proving the Apollo missions actually went there.



### LUNAR SURVEYS

NASA launched its Lunar Reconnaissance Orbiter in 2009 to map the Moon's surface in detail. It returned images of Apollo's landing sites, showing the Lunar Module descent stages, buggies, flags and astronaut footprints.



### MOON ROCKS

The six Apollo missions that made it to the Moon's surface brought back 380kg of rock samples. These have been found to be 200 million years older than any Earth rocks, and bear no signs of atmospheric or water erosion.



### INDEPENDENT TRACKING

Amateur astronomers used optical telescopes and basic radio equipment to track the Apollo missions in flight. And if they could do it, you can bet the Soviet Union was watching, and would have been well aware of any jiggery-pokery. **SF**

by **DR PAUL PARSONS**  
(@NASAProPlus)

Paul is a science writer and author of  
The Beginning And The End Of Everything  
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# SNIFFING OUT DISEASE

In just a few years, we could all be carrying a device in our pocket that detects the aroma of diseases like malaria or cancer before we even realise we're ill

by ROSIE MALLET

**P**icture a world where you no longer have to run a gauntlet of tedious, invasive tests when you suspect that something is amiss with your health. Instead, your smartphone or wearable device tells you that there's something wrong before you have any symptoms, and suggests that a trip to the GP might be in order, gaining you precious time to beat the illness. One day, perhaps you could be warned by a sensor that's implanted inside your body to keep tabs on your health.

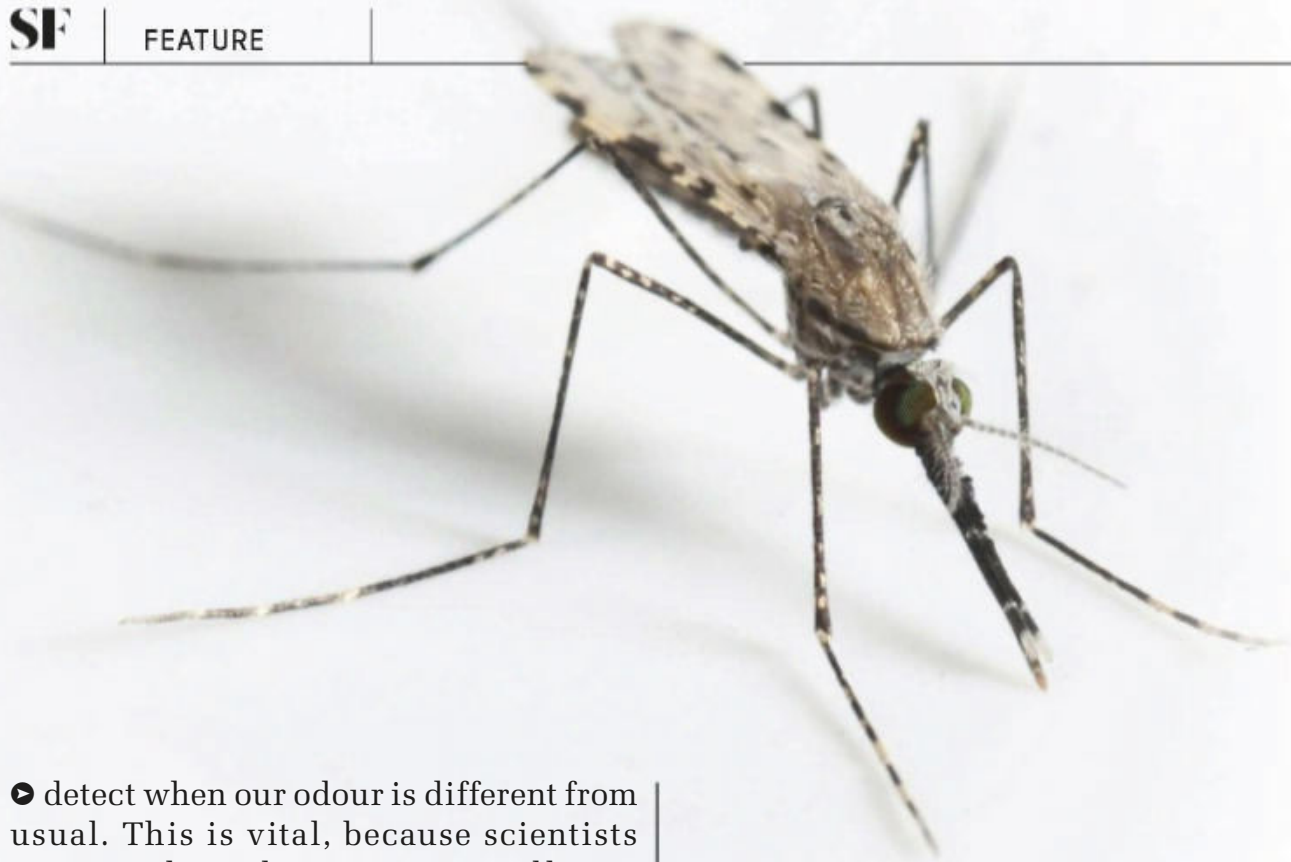
Such a world may not be that far into the future. Most of the technology already exists, and it has been right

under our noses all along. It relies on a resource that has been with us since the dawn of humanity: the power of smell. Scientists believe that tapping in to this hidden world of odours could pave the way to a major shake-up in our approach to healthcare.

## MAKING SCENTS

We constantly emit an aura of hundreds of volatile chemicals from our skin, our breath, and potentially even our gut microbes. Every smell is made up of a complex cocktail of compounds – like a recipe with multiple ingredients. Generally, these scents are too faint for us to detect, but to animals we're clouds of smells on legs, and they can ►





# “THE MOSQUITO HAS A HIGHLY SOPHISTICATED SENSE OF SMELL”

● detect when our odour is different from usual. This is vital, because scientists suspect that when we’re unwell, our unique aroma changes; each diseases could even have its own signature pong.

“If we can figure out these chemical signatures and mimic the animals’ smell-power, then we can use them to achieve earlier diagnosis and perhaps save lives,” says Prof James Logan, head of disease control at the London School of Hygiene and Tropical Medicine. And that’s exactly what he and his colleagues have been doing for one killer disease: malaria.

## GETTING BUGGED

The search begins with the mosquito. Although unpopular, it has one important asset: a highly sophisticated sense of smell, which it uses to hunt us down. It’s this

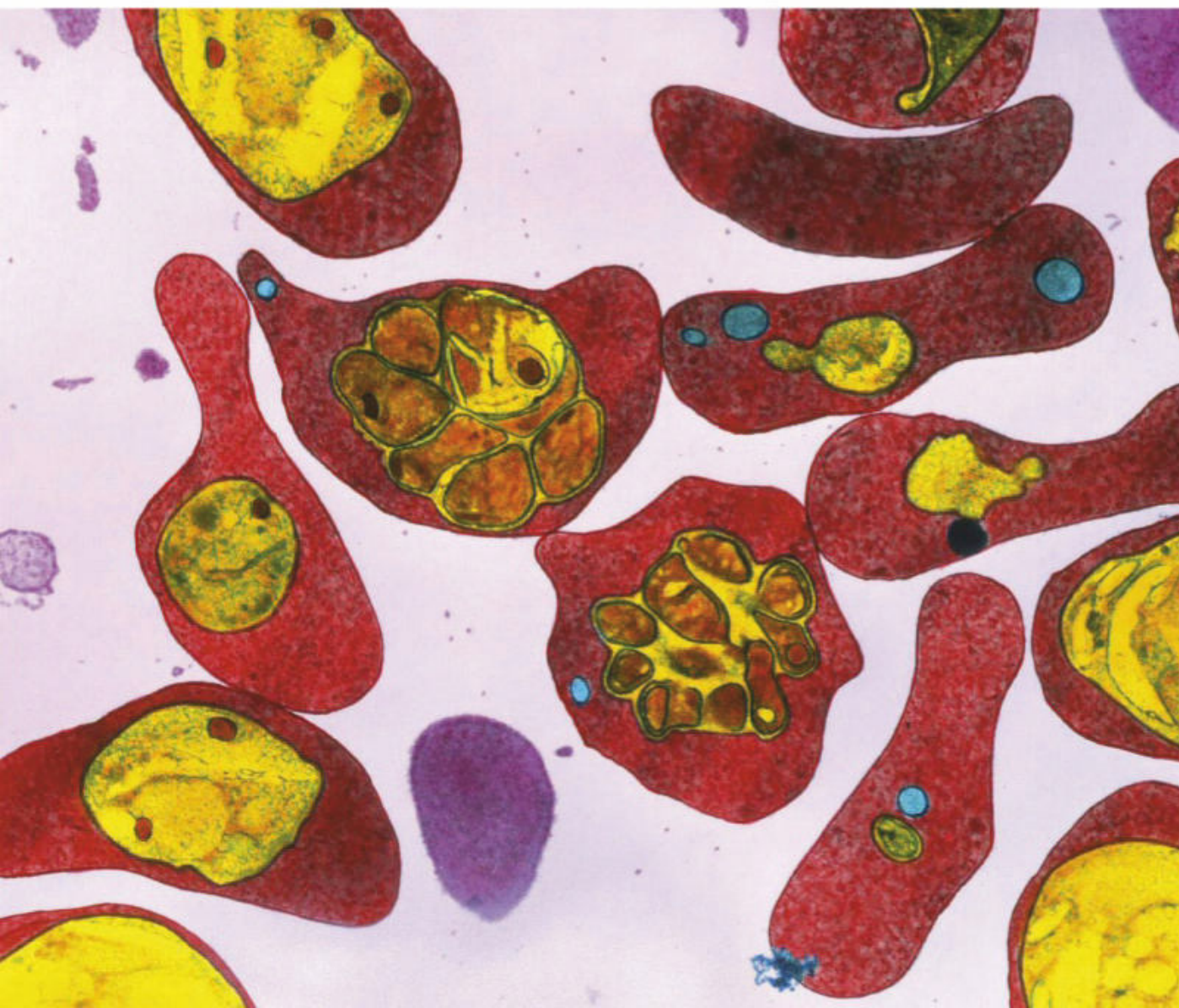
Red blood cells infected with the malaria parasite (yellow). Generally, symptoms appear once the red blood cells are affected

efficiency that makes it a threat to human life in those parts of the world where it carries the malaria parasite, *Plasmodium*.

Progress in the fight against malaria has stalled, partly because some people don’t realise they have the infection, and can pass it on when they’re bitten again. But Logan and his team of researchers discovered that when someone is infected by a malaria-carrying mosquito, they produce chemicals that change their smell, making them even *more* attractive to other mosquitoes. “So the malaria parasite is manipulating the human body to boost its chances of being transmitted,” says Logan. In a double-whammy, malaria also supercharges a mosquito’s sense of smell – all the better for sniffing out its human victims.

The researchers resolved to find out exactly what chemicals were attracting the mosquitoes. They collected odour samples from the feet of children with malaria, and separated these odours out into their component parts. Tiny electrodes were attached to mosquitoes’ antennae, which they use for detecting smells. They then exposed the mosquitoes to the different components, and measured the electrical responses of the smell receptors in the antennae. The culprits that triggered the highest response turned out to be mainly chemicals called aldehydes. These could be synthesised in the laboratory and kept in a bottle. More on that later.

But how do we turn a mosquito into a diagnostic tool? “It would be lovely if we could put a leash on a mosquito and take it round a community to find people infected with malaria. Not possible. But there is an animal we can do that with,” says Logan. Enter the dog – arguably the





# TAKING THE SMELL TEST

## Five diseases with telltale odours

world's best and most enthusiastic sensor.

### LAB REPORT

A dog's nose has 300 million receptors compared with our 5 million. In the same way as they point out illegal drugs in airports, dogs could be trained to sniff people's ankles for malaria, says Prof Steve Lindsay of Durham University's biosciences department.

The team worked with researchers in the Gambia to collect body odour samples from schoolchildren, asking them to wear nylon socks overnight. They also carried out blood tests to see which of the children had the malaria parasite: 30 of 175 children tested positive. None of the children had symptoms.

Then they presented the socks to two dogs trained to recognise malaria at the UK charity, Medical Detection Dogs (MDD). The dogs correctly detected the smell of malaria in 80 per cent of the samples from children who were positive for the infection. Among those who did not have the infection, the dogs got 91 per cent right.

"We think the malaria odour is so strong that the dogs can probably pick someone out from a crowd. So we're looking at using the dogs at ports of entry to countries to detect people carrying the malaria parasite," says Lindsay.

Once they're spotted, they can be treated before they spread the infection. "If it works well, we have a fast, non-invasive and affordable test to help keep countries malaria-free," he explains. "It might even be possible to eradicate malaria."

Other than detecting malaria, dogs are already known for their skill in sniffing out cancers, and are being studied for several other conditions. But they aren't the perfect answer for all our medical woes. They're not likely to be installed in every GP surgery, for instance. And you can only work with a dog for a short time before it loses concentration. In contrast, a machine can keep going forever.

That's where Logan's bottled malaria smell comes in handy. The chemicals can be used to develop a device that

Joy Milne is a 'super-smeller'. These people have a superior sense of smell and are sometimes sought after by perfume or wine manufacturers.

For Joy, however, her sensitive nose meant that she detected an unusual odour on her husband, Les. Initially she thought that perhaps he wasn't showering enough, but 12 years later he was diagnosed with Parkinson's disease. She only made the connection between the condition and the aroma after noticing the same smell on people at a Parkinson's disease support group. She has since worked with scientists at the University of Manchester to identify the chemicals underlying what she says is the characteristic smell of the condition, which could help lead to earlier diagnosis. Joy is now the linchpin for ongoing smell research. This is what she says about some common diseases:

### 1. PARKINSON'S DISEASE

This is a musky smell. It can become acrid due to a build-up of bacteria and yeasts in the sebum, the greasy substance that is secreted by our skin and overproduced in Parkinson's.

### 2. ALZHEIMER'S DISEASE

This has a milder human musk, like rye bread. The skin has a creamy yeast smell which can become stronger as the disease progresses.

### 3. TUBERCULOSIS (TB)

TB has an odour like stale beer. The smell is present in the breath, and changes as the disease progresses. The skin smells like "wet brown cardboard and brine".

### 4. DIABETES

Diabetes has a sweet smell with the combination of citrus and creamy pineapple. The smell can vary throughout the day, reflecting fluctuations in glucose levels and how well the diabetes is controlled.

### 5. CANCER

This smells of yeast or fungi, and different types of cancers have their own smell. It may also be possible to smell the difference when a patient is in remission following treatment.



Joy, who can smell Parkinson's disease, meets a rat that can sniff out tuberculosis





● mimics what the dogs do: an artificial nose. And malaria may just be the tip of the iceberg. “We know that other diseases have smells. If we can use the animals to help us pick out the right smells then we could develop diagnostics for any of these diseases,” says Logan.

#### ON THE NOSE

In the future, an artificial nose might be as simple as a patch that you wear on your skin like a plaster, or a wristband that changes colour when it detects the chemicals in your sweat, or it could be a smartwatch. It might even be a handheld electronic nose – an e-nose – tailored to sniff out the signature smell for the disease. Prof Krishna Persaud, a chemoreception expert at the University of Manchester, has developed an e-nose that’s about the size of an early mobile phone, and brings us a step closer to what has until now been science fiction. According to Persaud, we haven’t quite managed to develop a tricorder like the one used by *Star Trek*’s Dr McCoy yet, “but we are looking at a set of tools right now being developed by researchers around the world, which will help to transform medicine for the future,” he says.

The e-nose works by producing a chemical fingerprint after processing signals from its ‘nose’ – the sensor. When an odour hits the sensor it changes the electrical signal. One type of sensor uses a small quartz crystal that oscillates at a

frequency that depends on its mass. Incoming odour molecules change the mass of the crystal and the resulting change in frequency is measured.

Persaud and his team, however, are developing a new type of sensor – one that more closely mimics what an animal’s nose can smell. Using molecular biology, they’ve synthesised proteins that are naturally present in the mucus of animals’ noses, where they bind to odours and carry them to the smell receptors. The result is a super-sensitive bioelectronic nose that has to learn to detect changes in chemicals that happen when we get sick.

But another scientist wants to take it a step further, by putting a nose in your phone. Dr Andreas Mershin, director of the Label-Free Research Group at the Massachusetts Institute of



ABOVE LEFT: This very good girl is being trained to identify the smells of diseases

LEFT: Dr McCoy could wave his tricorder over a patient to diagnose their ailments. We’re not quite there yet, but the device is becoming closer to reality

ABOVE RIGHT: Dr Andreas Mershin with his prototype device he’s developing that fits in your phone and sniffs out cancer



Technology in the USA, says we live with our smartphones 24/7 so it makes sense to use them to keep tabs on our health.

His vision is to create an artificially intelligent, dog-like nose. This 'nano-nose' would constantly monitor your smell from your phone. It could even save your life. "Eventually it might even be something you install inside your body so you never lose it," he says.

Mershin has been learning how to perfect his nano-nose from the Medical Detection Dogs in the UK, and he and his colleagues have created a device even more sensitive than the dog's nose. But the e-nose has a fundamental flaw: it doesn't have a brain.

"We made a big mistake when we thought the dogs are so good just because their nose is so sensitive," he says. "A dog can learn to detect a type of cancer in a sample. Then that dog, without additional training, can spontaneously recognise



**"BY UNDERSTANDING  
YOUR OWN BODY SMELLS,  
YOU WILL BE IN CHARGE  
AND THE DOCTOR WILL  
BE THE LAST PERSON  
YOU TURN TO"**

other types of cancer – even though they have no identical molecules. So the dog understands something more than just the volatiles that are flying around. No machine can achieve that."

The key, he believes, is in how the handler trains the dog. "I want the phone to be your dog and you to be the handler – it learns your personalised scents so when they change, it can warn you," says Mershin. It will alert you, for instance, if a mole becomes malignant. "Maybe your phone says, 'you know what, you should probably see a dermatologist, something is smelling iffy'."

The e-nose could become the most powerful diagnostic tool developed to date. It will allow us to flip the responsibility for healthcare on its head, Mershin predicts. "By understanding your own body smells, you will be in charge and the doctor will be the last person you turn to." **SF**

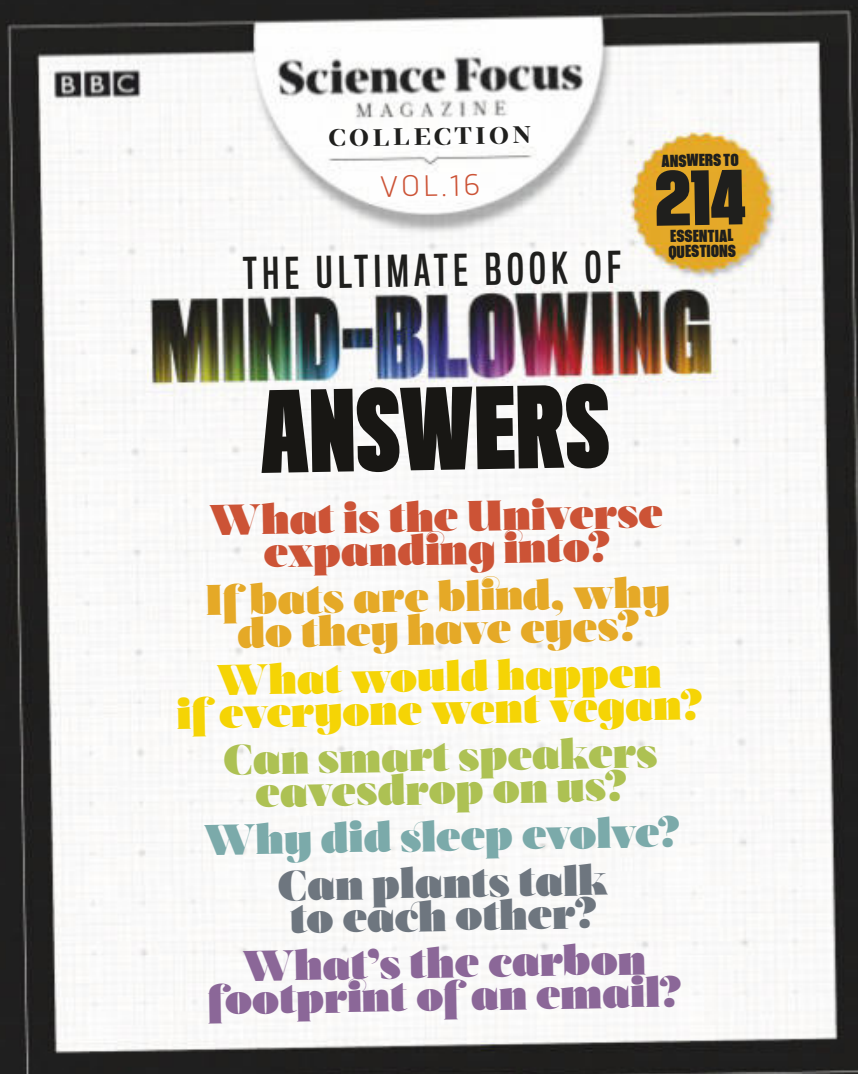
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*Rosie is a freelance science writer, who specialises in health and medicine.*



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# Q & A

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JENNY HARRIS, SUTTON

## DO ANIMALS GET EMBARRASSED?

It's hard to imagine that a pug dressed up as a hot dog doesn't feel embarrassed, especially if it's displaying expressions that we normally associate with that emotion, such as looking away. But perhaps the dog is just uncomfortable in the costume, or even scared. Likewise, an animal which has done something we deem to be naughty or silly might appear to be embarrassed, when it's actually just responding to our body language and anticipating a reaction from us. While scientists agree that some animals are capable of experiencing basic emotions, a lack of research means that the jury is still out on these more complex ones. CC





CIAN MCCARTHY, CORK, IRELAND

## WHEN WE START UPLOADING OUR BRAINS TO COMPUTERS, WILL OUR SENSE OF SELF BE UPLOADED TOO?

Our sense of self emerges from the activity of a poorly understood network of neurons, glial cells and blood vessels in the brain, which together produce the electrical and chemical processes that give us our thoughts and consciousness. One day, it might be possible to scan all of this activity with perfect fidelity – this would be a hugely intensive process, involving recording the activity of every cell and chemical at an atomic level. This digital scan could be turned into a computer simulation, essentially allowing you to go on living after death. In

theory, the simulated version of your brain would believe that its sense of self had been successfully uploaded, transferred from a biological body to an artificial one.

However, it's not quite as simple as that. If scientists can develop a way to perfectly scan the brain without destroying it (which isn't a given), then your original brain (and sense of self) would still exist, trapped in a body that will eventually fail. Your digital self might come to the realisation that it's a copy, triggering an existential crisis.

And what if someone decides to make a hundred copies of this digital self? Now there are a hundred digital versions of 'you', each with its own sense of self. Is each of these selves equally valid? Does the second sense of self know that it's the original copy, and thus expect a higher status? Could the separate selves decide to share their experiences and become a super-intelligent 'hive mind'?

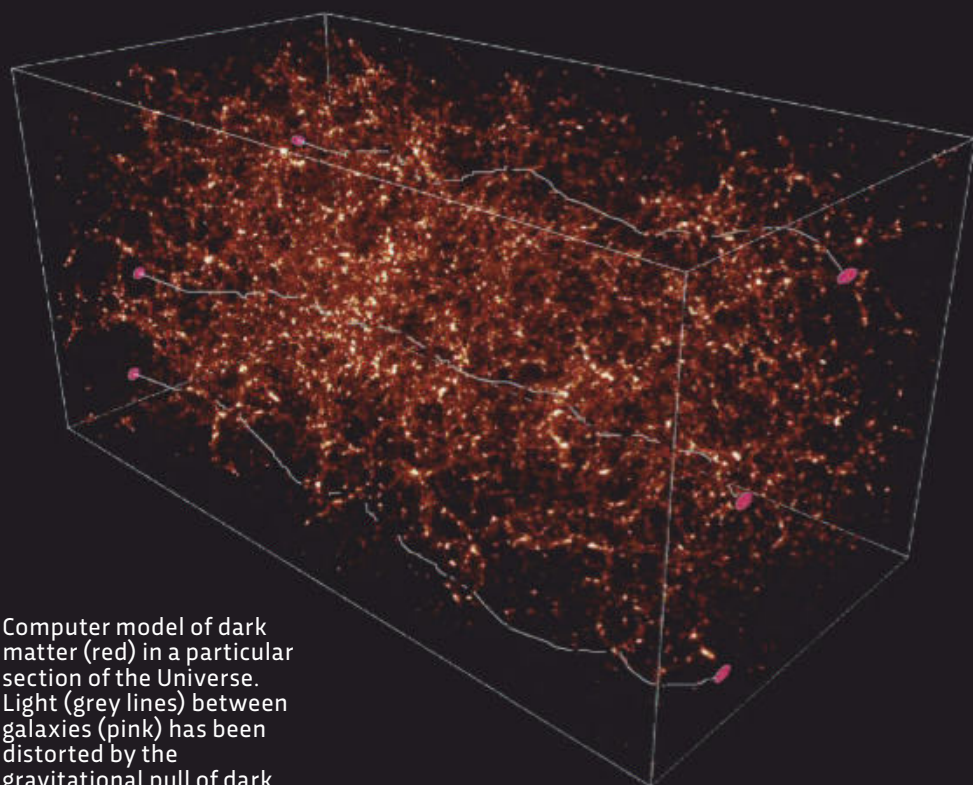
We don't yet know the answers, but one way to limit any potential complications might be to become immortal piece by piece. We naturally change as we age, so if you slowly replaced failing biological tissue with computerised prostheses, then by the time all of your body and brain had been replaced, your sense of self will have been transferred without leaving behind a biological remnant. Just watch out for the delete key... a digital brain is much easier to wipe than an organic one! **PB**

EDWARD SEYMOUR, HOVE

## HOW MANY STATES OF MATTER ARE THERE?

There are now as many as eight: the number creeps up as science advances.

Schoolkids are taught about three physical states: solid, liquid and gas. A fourth is hot, charged gas (plasma), which consists of positively charged ions and free electrons. In 1995, scientists created a new state called 'Bose-Einstein condensate' by cooling gas to within a few degrees of absolute zero ( $-273^{\circ}\text{C}$ ), at which point molecular motion almost stops and the atoms behave en masse like a single atom. Earlier this year, researchers reported another new state for certain metals, where atoms exist as both solid and liquid at the same time. Two other states are space-related: 'quark-gluon plasma', which made up the Universe up to a few milliseconds after the Big Bang, and 'degenerate matter', a highly compressed state that's found in stars. **ED**



Computer model of dark matter (red) in a particular section of the Universe. Light (grey lines) between galaxies (pink) has been distorted by the gravitational pull of dark matter – without it, the lines would be straight

MERLIN BATCHELOR, NORWICH

## COULD 'DARK MATTER' JUST BE DEAD STARS AND PLANETS FLOATING IN THE DEPTHS OF SPACE?

Some astronomers have indeed theorised that dark matter might just be ordinary matter that we cannot see, rather than an exotic, as-yet-undiscovered particle. This ordinary matter could include black holes, neutron stars, brown dwarfs, white dwarfs, very faint red dwarfs and even solitary planets. These objects, collectively known as MACHOs (Massive Astrophysical Compact Halo Objects), emit very little light, but they can be detected if they pass in front of or near a background object (via the way that their gravity bends the light from the more distant object). However, studies to date have concluded that MACHOs can only account for a tiny fraction of the missing mass in the Universe. So the nature of dark matter remains a mystery. **AGu**



## WHAT CONNECTS

### FLORENCE AND THE MACHINE, AND ORION?



1. The British indie rock band Florence and the Machine released the song *Dog Days Are Over* in 2008 as the second single from their debut album *Lungs*.



2. The title is a reference to the 'dog days of summer' – the hot, sultry days in July and August when the weather is usually at its most uncomfortable.



3. The phrase goes back to the Ancient Greeks, who used it to refer to the time following the rising of the 'Dog Star' in the Northern Hemisphere.



4. The Dog Star is also called Sirius – the brightest in the night sky. It gets its name because it faithfully follows the constellation of Orion the hunter across the sky.



HARRY GREEN, LONDON

### HOW HOT WOULD A PAVEMENT HAVE TO BE IN ORDER TO FRY AN EGG ON IT?

If the sunshine is beating down for hours, the pavement can get hot enough to at least partially cook an egg. But for a fully cooked egg, which needs temperatures of around 70°C, you're better off with a manhole cover. These tend to get hotter than the surrounding pavement because they're made from metal and heat up more when exposed to the same amount of sunlight. They also have an insulating layer of air beneath them, reducing the amount of heat that's conducted away. **RM**

CLARE LINNELL, GUILDFORD, SURREY

### WHY DO HUMANS FEEL BETTER AFTER THEY HAVE CRIED?

The popular idea that crying is beneficial and 'cathartic' is actually the subject of intense debate among emotion researchers. A study of personal diaries conducted by the University of South Florida found that people generally reported feeling down on the days before and after a good cry. Lab studies using sad films have also found that most people actually feel worse immediately after crying. However, a recent Dutch study found that a beneficial effect of crying kicks in after about 20 minutes. The precise reasons why crying may (sometimes) be beneficial remain unknown, although there has been plenty of speculation: crying may prompt us to seek out mood-boosting activities; it could trigger physiological changes that help us to relax; and of course crying can invite love and support from others. **CJ**





## EXISTENTIAL FEAR OF THE MONTH...

# I'M LIVING IN A SIMULATION AND NOTHING IS REAL

Versions of this idea have been discussed all the way back to antiquity. The modern interpretation was popularised by Oxford University philosopher Nick Bostrom in 2003 and has since been expanded by many others, including MIT professor Rizwan Virk. The simulation argument supposes that computer power will continue to increase to the point where it is possible to model enough of reality to mimic everything that we are currently able to perceive and measure. This needn't be as complex as a complete model of the Universe. The stars in the sky could be simulated just as points of light, with no other features until we point a telescope at one. If we assume such

simulations are possible, then it seems inevitable that there will be more than one; and thus, statistically, we are more likely to be in one of the simulations than the single 'true' reality.

Even if we one day manage to build such a simulation, that doesn't rule out the possibility that we are nevertheless in a simulation of our own. In fact, we could be in a simulation within a simulation, within a simulation that extends endlessly above us. But all any of us will ever know is limited to what we can directly perceive, and whether our 'reality' is more or less real than some other version we can imagine is ultimately a fairly meaningless question. *LV*



# 6

The amount of time, in hours, that 188 head lice were submerged for.

All of the lice survived their dip.

About half the lice were still alive after 24 hours underwater – so if you think a lengthy soak in the bath will drown the blighters, think again!

ANDREW BLACK, EALING

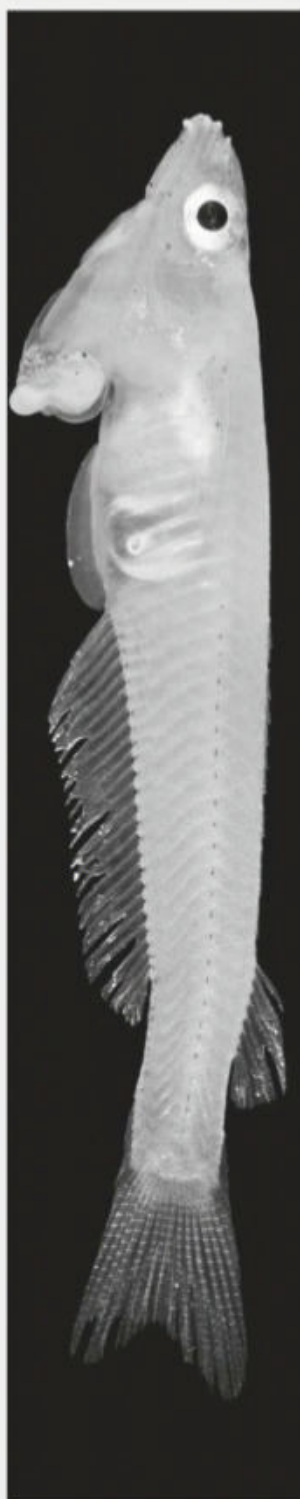
## WHATEVER HAPPENED TO IRRADIATED FOOD?



Food waste is a huge problem: the UK alone is estimated to bin over 10 million tonnes of food every year, worth around £20bn. Of this, a substantial proportion – around 20 per cent – is the result of spoilage due to bacterial action. A really effective way of reducing spoilage exists, but it's never caught on: exposing food to radiation.

Over 100 years ago, experiments showed that X-rays kill off bacteria, and by the late 1950s the first commercial food irradiation plant was operating in Germany. Today, treatment of many forms of food using intense gamma radiation has been approved in over 60 countries – including the UK. Yet despite its ability to cut both food waste and food poisoning, the method has never gone mainstream. That's largely because of consumer resistance. Despite hundreds of scientific studies showing it does not make food radioactive or undermine its quality, most people just won't touch it. *RM*



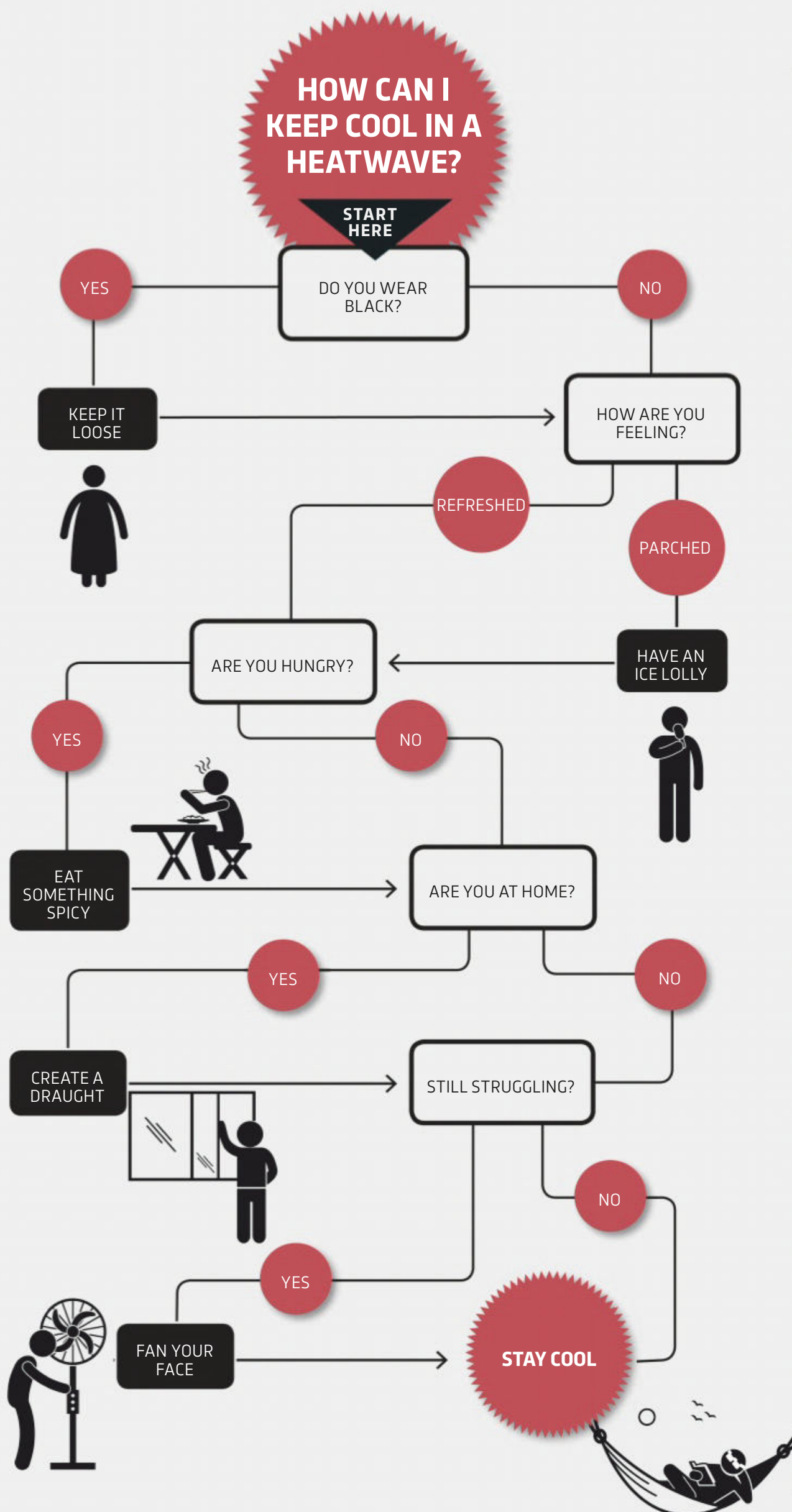


JASON GOODYER, BRISTOL

## I'VE HEARD THERE'S AN ANIMAL WITH A PENIS ON ITS HEAD. IS THIS TRUE?

Yes. The males of the *Phallostethidae* family of fish, which live in rivers in Southeast Asia, have a sex organ positioned under their chin, just behind their mouth. It consists of a rod for injecting sperm and a separate serrated hook for holding on to the female's head, which guarantees no sperm gets lost in the strong river currents. **LV**

## ALGORITHM YOUR LIFE



### KEEP IT LOOSE

A 1980 study found that the black robes worn by the Bedouins in the desert keep them cool by allowing air to flow between the robe and the skin – the colour is largely irrelevant here. So if you're wearing black, go baggy.

### HAVE AN ICE LOLLY

Melting ice requires heat energy to rearrange the molecules into liquid form. So sucking an ice lolly will use up some of your excess heat, cooling you 30 per cent more than the same volume of cold drink.

### EAT SOMETHING SPICY

Capsaicin in chillies tricks the thermoreceptors in your mouth into thinking you're hotter than you really are. This makes your skin flush, and you also sweat more. Both are efficient ways to shed heat quickly – provided there's a breeze.

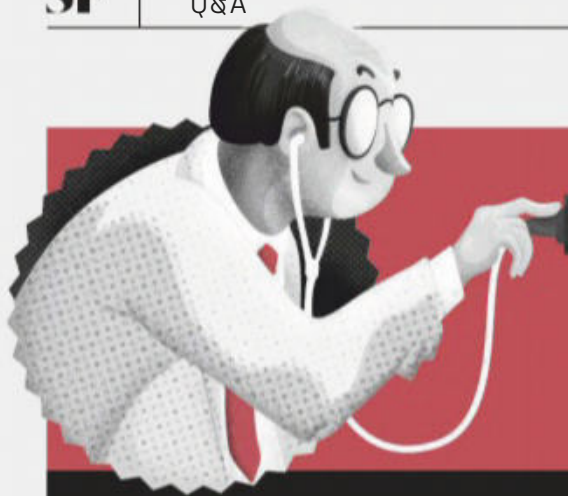
### CREATE A DRAUGHT

Instead of opening every window in the house, open just the upstairs windows on the sunny side of the house and the downstairs windows that are in shade. The pressure difference between the two will pull cool air up through the house.

### FAN YOUR FACE

The skin on your forehead has an especially large number of sweat glands (around 175 per square centimetre), so fanning yourself here will help cool you down quickly.





## DEAR DOCTOR...

DELICATE ISSUES DEALT WITH  
BY *SCIENCE FOCUS* EXPERTS

### I'VE GOT A CRACKING SUNTAN AT THE MOMENT. WILL IT PROTECT ME FROM THE SUN?

Afraid not. A suntan is a sign that the damage is already being done. When your skin is exposed to the Sun's ultraviolet (UV) radiation, the body responds by producing the dark pigment melanin. This helps to protect your skin by absorbing UV energy, but it gives only a limited amount of protection, especially in fair-skinned people. UV radiation will still be able to penetrate skin cells and damage the DNA, increasing your chances of developing skin cancer. So if you're going out, make sure you slather on the sunscreen (dermatologists recommend at least SPF 30). If you love having that post-holiday glow, fake tan might be the way to go in future. **HG**

### WASPS SEEM TO ADORE ME. WHAT'S THE BEST WAY TO GET THEM TO GO AWAY?

Wasps are attracted to white, bright blue and yellow, but can't see red, so plan your wardrobe accordingly. Their vision is also optimised to look for the sudden, sharp movements of insects, so wildly flailing as you try to swat a wasp will just make it more determined. Killing a wasp also releases pheromones that will attract other wasps nearby. Instead, calmly trap the wasp under a glass, so it can't return to the nest and tell the others where to find your food. A 2012 study tested the wasp-repelling properties of different essential oils and found that a mix of clove, geranium and lemongrass oil was the most effective, so try a dab behind each ear. **LV**



### WHY DOES HOT WEATHER MAKE ME TURN INTO THE HULK?



In the 1990s, researchers proposed the 'heat hypothesis' to explain the fact that violent crimes go up in the summer (the US murder rate, for example, rises by about 2.7 per cent), and that aggressive acts are often more common in hotter countries – the basic idea being that warmer temperatures make us more prone to losing our temper and lashing out.

Of course, there are many alternative explanations for these heat-crime links, such as more people being out and about in hot weather (thus increasing the risk of random altercations). But multiple studies have confirmed that you're not alone in finding that hot weather makes you liable to tantrums. In 2016, for example, psychologists at Texas Tech University

found that American football players were more likely to commit aggressive fouls during hotter weather.

The main psychological explanation is that because heat makes us feel physically uncomfortable, we're more inclined to aggressive thoughts and to interpret things in a negative way. There are tentative biological explanations, too, with recent Scandinavian research identifying a link between higher temperatures and raised serotonin levels – a brain chemical that's related to impulsivity, among other things.

So just like Bruce Banner, it's probably worth making the extra effort to keep cool in hot weather, both literally and emotionally. **CJ**

LEON DAVIES, LONDON

## HOW DID QWERTY END UP ON OUR KEYBOARDS

The arrangement that we're so familiar with today evolved over many iterations. When newspaper editor Christopher Latham Sholes first patented a design for a typewriter in 1867, he arranged the keys alphabetically. Over the next few years, he experimented with different layouts, such as moving most of the vowels to the top row, and consonants lower. The idea that Sholes's layouts were designed to slow down typists, and hence avoid jammed keys, is now thought to be an urban myth. In fact, there's evidence that Sholes was actually trying to speed up typing, following feedback from telegraph operators. Either way, when the rights to manufacture the device were sold to E. Remington and Sons in 1873, his upper row was QWE.TYIUOP, and it took only a couple of tweaks to give the QWERTY layout that's now widespread. If you look at a keyboard, you can still see the remnants of Sholes's first alphabetical layout in the middle row keys: DFGHJKL. **PB**

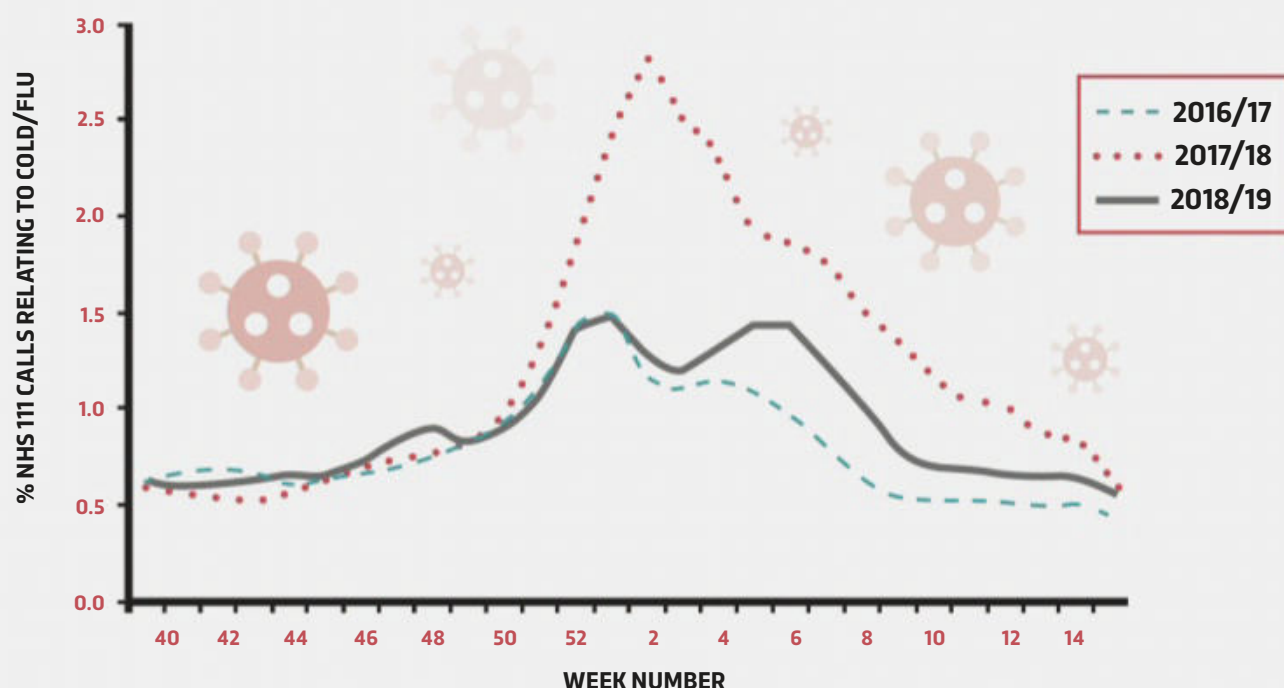


ROSIE STEVENSON, DERBY

## WHY DO GLASSES MAKE PEOPLE LOOK MORE INTELLIGENT?



It's an association that starts early: when primary school children are asked to draw a scientist or 'smart person', they tend to depict them with glasses (perhaps influenced by spectacle-wearing characters like Harry Potter). This association may be because we tend to assume that short-sighted people are more 'bookish' – a stereotype with more than a grain of truth. Lack of time spent outside has been shown to contribute to short-sightedness, as has time spent engaging in close-up work such as reading. **CJ**



ANDREW CIREL, VIA EMAIL

## WHY DON'T VIRUSES LIKE THE FLU DIE OFF WHEN NO ONE IS ILL?

Strictly speaking, viruses can't 'die off' as they're just inanimate strips of genetic material plus other molecules. But the reason that they keep coming back is because they're always infecting someone somewhere; it's just that at certain times of the year, they're less able to infect enough people to trigger a full-blown epidemic.

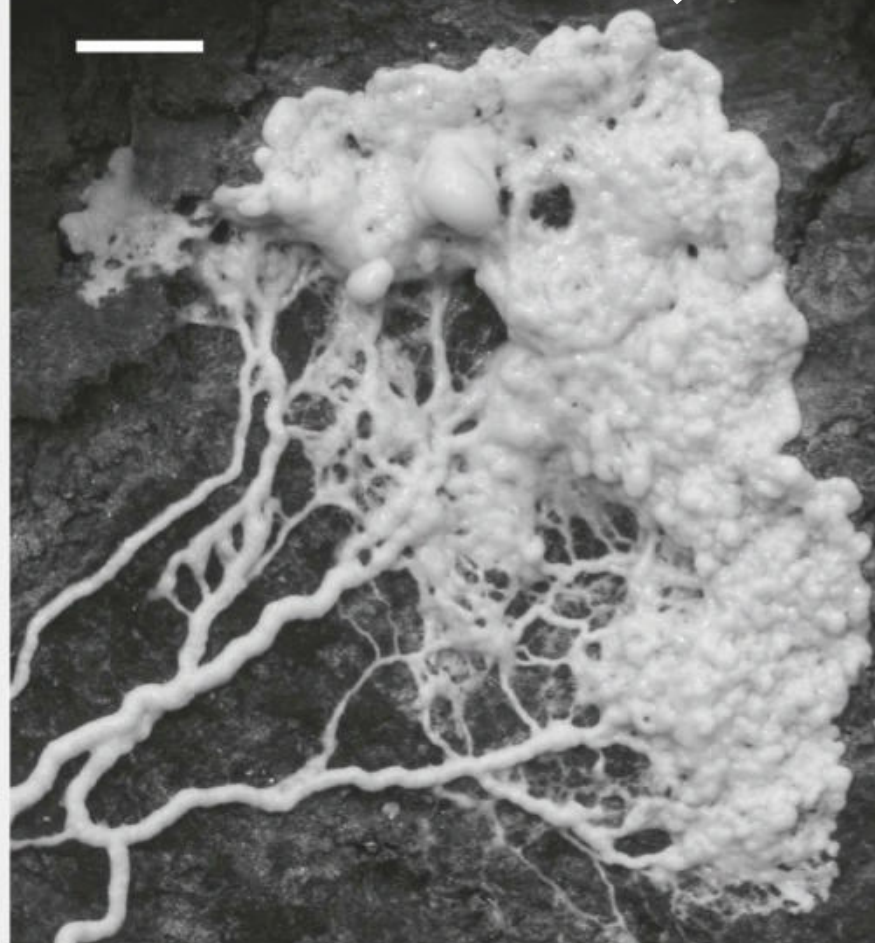
Many viruses flare up during the winter because people spend more time indoors in poorly-ventilated

spaces, breathing in virus-laden air and touching contaminated surfaces. The shorter days also lead to lower levels of vitamin D, and this weakens our disease-fighting immune system. Experiments also suggest that the flu virus in particular remains infectious for longer in low temperatures.

But even when conditions aren't ideal, viruses will find enough people to infect to ensure their survival, until they can come roaring back in an epidemic. **RM**

## NATURE'S WEIRDEST CREATURES...

### SLIME MOULD (*PHYSARUM POLYCEPHALUM*)



Deep in the woods lurks a creature with no mouth, eyes, or brain. An oozing, yellow mass that thrives in decaying leaves and logs. Let's celebrate *Physarum polycephalum* – a species of slime mould that thinks without a mind.

In its early life, this creature exists as a single-celled organism. But when times get tough, it has a trick up its sleeve. Each *P. polycephalum* can merge with the individuals surrounding it, forming a super-sized cell that's capable of reaching a metre in length that can slowly creep towards nearby food (usually fungal spores and bacteria).

Recently, *P. polycephalum* has become the lab rat of slime mould research. It's able to

escape from traps and find its way around mazes, and it's been shown, when given a choice, to seek out the most nutritious food – porridge oats, apparently. A particularly memorable experiment involved *P. polycephalum* gradually learning to 'ignore' chemicals that had been placed to block its path to food. This behaviour suggests a primitive form of memory, and no one knows quite how it manages this feat.

Worldwide, there are thought to be around 900 slime mould species, yet many more are likely awaiting discovery. You may think them primitive, certainly, but you'd be wrong. What we achieve in a trillion cells, they manage with just one. **JH**



## OLD WIVES' TALES...

### THE FULL MOON MAKES PEOPLE MAD



The origins of this idea date back at least to the Ancient Greeks, with Aristotle 2,300 years ago claiming that the Moon could influence the human mind. But madness wasn't the only outcome: the original meaning of 'lunatic' referred to epilepsy rather than insanity. The Roman naturalist Pliny the Elder argued that the Moon was able to exert its influence via the water content of the brain – rather like the tides. This is now known to be nonsense: the forces involved are far too small.

Even so, the belief persists and has been investigated scientifically many times. A 1985 review of dozens of studies of alleged links between the Moon and everything from psychiatric issues to criminal behaviour found no compelling evidence. But it still remains an active research topic. Earlier this year, the respected journal *BMJ Open* published a study claiming to show that a full Moon actually makes murders *less* likely, although the author admits that the reason isn't clear, and that other factors may play a role.

So how did the idea of a lunar influence on humans get traction in the first place? One suggestion is that in ancient times a bright full Moon was more likely to disturb sleep – and sleep deprivation is known to exacerbate mood disorders in some people. **RM**

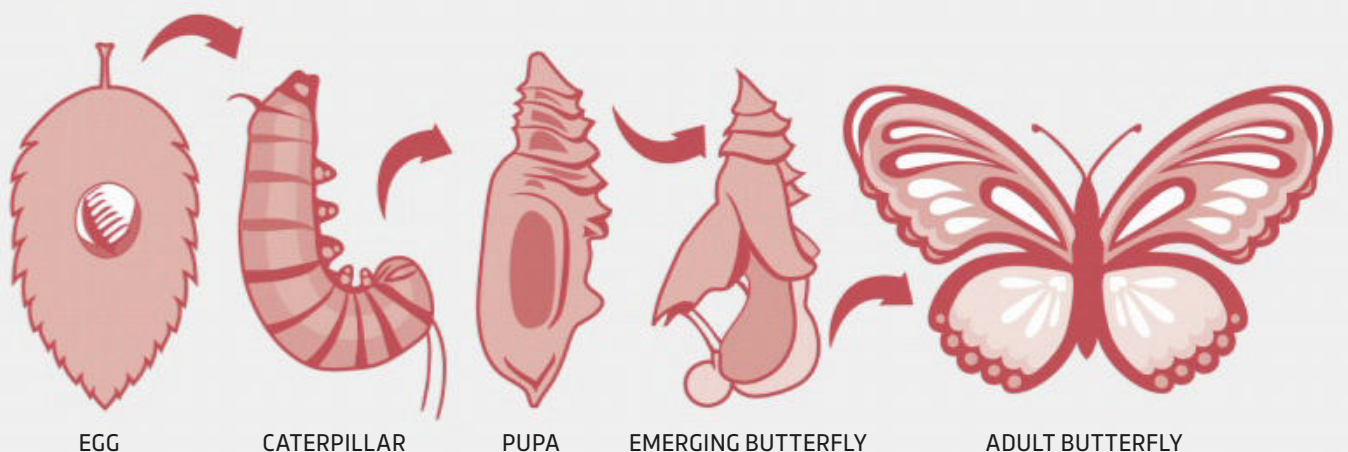
RUTH DIETRICH

### WHAT HAPPENS TO THE LIGHT THAT'S BEEN SUCKED INTO A BLACK HOLE?

Once a particle of light ('photon') passes the 'event horizon' of a black hole, it can no longer escape, but there's nothing to suggest that it is destroyed. Like matter, the photon is rapidly sucked towards the 'singularity' at the centre of the black hole, where a huge mass is packed into an infinitely small space. What happens to photons at these extreme conditions, however, is one of physics' big unanswered questions. **AGu**

JAMES COLLEY, VIA TWITTER

### WHAT ACTUALLY HAPPENS WHEN A CATERPILLAR BECOMES A BUTTERFLY? IS IT A POKÉMON SITUATION OR MORE OF A CRONENBERG THING?



It's more of a messy, Cronenberg-esque transformation than a tidy Pokémon one. When a caterpillar starts to change into a pupa (or 'chrysalis'), its own digestive enzymes begin to break down most of its cells into a chemical soup. Some of the caterpillar's structures do remain intact, however, such as the gut, the tracheal tubes (for breathing), and some of the central nervous system. Also resistant to the transformation process are clumps of cells called 'imaginal discs', which are contained within the caterpillar's body for its entire life. During

metamorphosis, the imaginal cells divide rapidly. At first, these are treated as invaders and attacked by the caterpillar's immune system. But eventually the imaginal cells overwhelm the dwindling caterpillar cells and begin to use the raw materials around them to assemble new butterfly structures, such as wings, legs, eyes and antennae. These structures eventually connect up with the remaining caterpillar parts, and the newly assembled butterfly emerges. The whole process can take just two weeks in some species. **LV**





TOBY GRAHAM, SHREWSBURY

## WHY CAN'T I TICKLE MYSELF?

It's all down to the lack of surprise. A 1998 study at University College London found that, when someone tries to tickle themselves, the brain reduces the intensity of the sensation by damping down signals in the somatosensory cortex – the brain region that processes touch. If someone else tickles us, however, the brain doesn't know what's coming, and this mechanism doesn't kick in – and we bear the full brunt of the tickling. This probably evolved so that we are able to differentiate between our own touches and those of another animal, such as a bug that could sting or transmit disease. **LV**



ROB BANINO, BRISTOL

## WHAT EVOLUTIONARY ADVANTAGE DID SNAKES GAIN BY LOSING THEIR LEGS?

It's thought that snakes lost their legs 100 to 150 million years ago, but debate is still raging as to whether their limbed ancestors were aquatic or terrestrial. The evolution of a long, legless body could be beneficial to life underwater as it would enable eel-like swimming. But it could also be beneficial on land, making burrowing and hunting underground easier. Either way, we can still see traces of their legs today: boas and pythons, the most ancient surviving snakes, have tiny leg bones buried in the muscles towards their tail. The more advanced snakes, however, have lost them completely. **CC**

ADAM KING, HUDDERSFIELD

## HOW MUCH MONEY IS ESTIMATED TO EXIST ON EARTH?

As with so much in finance, the answer isn't straightforward. Economists distinguish between various types of money, ranging from individual savings deposits to the reserves held by central banks. But taking 'money' to be coins and notes, statistics collated by the Swiss-based Bank for International Settlements suggests there's over \$6,000bn worth of the stuff out there. This figure does not, however, include the vast amount believed to be lost down the back of the world's sofas. **RM**



## QUESTION OF THE MONTH

ROGER BRITTON, LANNER

## HOW CAN ONE EYE ALONE PROVIDE DEPTH PERCEPTION?

One of the main ways our brains perceive depth is by using a technique called 'binocular disparity', which compares the slight differences in view from each eye to determine the distance to objects. If you close one eye, however, you'll notice that you can still perceive depth. This is thanks to a number of extra visual cues that our brains exploit. For example, we know the size of things from memory, so if an object looks smaller than expected we know it's further away. Our brains also understand perspective, where parallel lines (such as train tracks) get closer together as they stretch into the distance. There's also a nifty mechanism called motion parallax: when we're moving, objects appear to shift by different amounts, depending on their distance from us. **HG**

### WINNER

Roger wins a 50th anniversary edition of the *Apollo 11 Owners' Workshop Manual* that takes a new look at the legacy of Apollo 11, and *NASA Moon Missions*, which explores the five successful lunar landings that followed Apollo 11. Worth £46 in total. **haynes.com**



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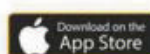
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# RADAR

WHAT'S LIGHTING UP OUR ANTENNA THIS MONTH



## 1. Shhhhh

This major new exhibit at the Science Museum explores just how GCHQ, the UK's intelligence and cyber agency, has kept its secrets for the last 100 years.

**Top Secret: From Ciphers To Cyber Security**  
Opens 10 July  
[sciencemuseum.org.uk](http://sciencemuseum.org.uk)

## 2. Prom night

The Royal Albert Hall will be filled with the sound of space this summer, or at least melodies written by composers who have tried to evoke the grandeur of the cosmos. Not to be missed.

**BBC Proms**  
21 July, BBC Four

## 3. Just a bit of fun

The Festival of the Spoken Nerd clan return with friends in this show of comedy, live experiments and miscellaneous experts.

**An Evening Of Unnecessary Detail**  
26-27 July,  
Bloomsbury Theatre  
[fotns.com](http://fotns.com)

## 4. Soak in the Sun

If you can't get enough sunshine this summer, head to the Science and Industry Museum, who've set up an indoor beach, a solar storm walkthrough and an Antarctic sunrise screening.

**The Sun**, from 20 July  
[bit.ly/sci\\_ind\\_mus](http://bit.ly/sci_ind_mus)

## 5. Moon monkeys

Brian Cox and Robin Ince take over the Kennedy Space Center for this episode of *The Infinite Monkey Cage*, dedicated to the anniversary of the first human to walk on the Moon.

**The Infinite Monkey Cage**, BBC Radio 4,  
[bit.ly/monkey\\_cages](http://bit.ly/monkey_cages)

## 6. Dark matters

This exhibition of events at the London Science Gallery draws on physics, philosophy and art to grapple with this most intangible stuff in the Universe, dark matter.

**Dark Matter**,  
6 June – 26 August  
[bit.ly/london\\_sci\\_gall](http://bit.ly/london_sci_gall)

WELLCOME TRUST, GETTY IMAGES X3, NASA

Did you know that  
**90 PER CENT OF OUR DNA**  
is similar to domestic shorthair cats? Yeah,  
we're not special. p90



# 150ml



The amount of milk held in the bottles of the Elvie breast pump. The pump automatically pauses when the bottle is full. p94



## Profile

# PRIDE BEFORE A FALL

**HUMANS LIKE TO BELIEVE THAT WE ARE SOMEHOW DIFFERENT FROM OTHER ANIMALS. NICHOLAS MONEY, AUTHOR OF *THE SELFISH APE*, ARGUES THAT WHAT MAKES US UNIQUE IS OUR SELF-ABSORBED DESTRUCTIVENESS**

### WHAT ARE YOU TRYING TO ACHIEVE WITH THIS BOOK?

It's a book that summarises in a succinct fashion the human condition from a biological perspective, and I think it places us within a proper context.

Hopefully it will lead readers away from the idea that we are an exceptional species. There have been so many books, and media attention, focused on the measures of human biology that speak to our triumphant place in nature. Add to that the way that we flambé the planet and the way we talk about artificial intelligence, it feels as though we're beginning to acquire the tools to obtain an almost godlike status.

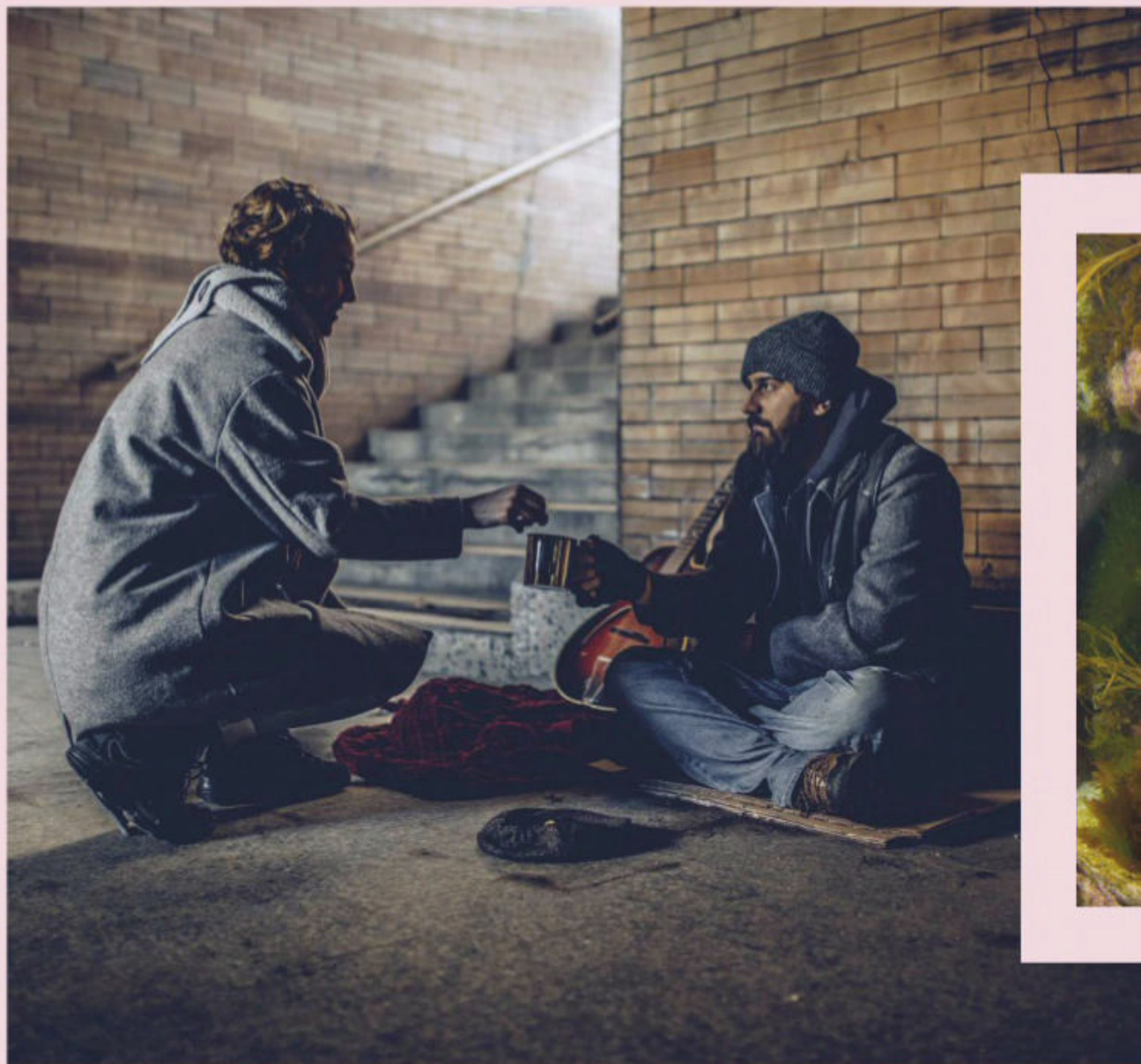
But in my view, and the point I make in my book is, humans are quite unexceptional, by more measures than we care to admit.

We are, however, exceptional in our destructiveness, and I think that this needs to be said to counter the voices that seek to elevate us above the rest of nature.

### WE HUMANS LIKE TO THINK OF OURSELVES AS SPECIAL. WHAT IS IT THAT DISTINGUISHES US FROM OTHER ANIMALS, BIOLOGICALLY SPEAKING?

The size of the human brain, that is the metric that separates us from other organisms, although of course, there are larger brains on this planet.

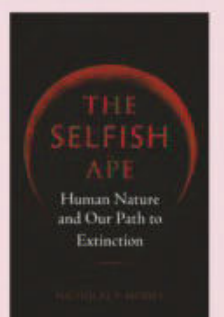
There's also our possession of language and the dextral finesse we have – so, the fact that we've got hands.



**“Is an earthworm less successful than a human? They’ll probably be here a long time after we’re gone”**

As smart as killer whales might be, and pilot whales certainly, they can't alter their environment in any conscious fashion. They can go out there and feed and mate and so forth, but we can actually build things with our hands. We've certainly perfected tool use.

So, certainly there are many ways in which humans differ from other species, but of course you could apply the same thing to any other species on the planet; in what way is a bumblebee different from humans? Certainly, there are specifics about the human condition, but in many other ways, we're not that exceptional. For example, it has been fashionable for a long time to speak about



**THE SELFISH APE**  
BY NICHOLAS MONEY  
(£14.99, REAKTION BOOKS)





ABOVE: We humans are destructive and treat other beings with less regard than ourselves

LEFT: Charity and community are admirable parts of the human psyche, but we still haven't escaped from self-adoration

human consciousness as a unique characteristic of *Homo sapiens*, but we now know that this is without foundation. We see evidence of consciousness in many other animals, and certainly in insects; dragonflies and so forth. They are tremendously sensitive organisms with sophisticated nervous systems and sensory systems.

**IN ONE SENSE, SCIENCE HAS PUT A LOT OF EFFORT IN OVER MANY CENTURIES TO PROVE WE'RE NOT SPECIAL, THAT WE'RE NOT AT THE CENTRE OF THE UNIVERSE. WE'RE NOT EVEN AT THE CENTRE OF OUR SOLAR SYSTEM. SO WHERE DID THE IDEA COME FROM IN THE FIRST PLACE?**

To answer that you have to ask is 'what's the source of our narcissism?' I think the answer probably lies in our success in warfare. The fact that we wiped out other hominids. I mean, some of them were extinguished by climate change in their time, but I think the fact that we were so successful at wiping out our competitors, hunting our prey and changing our environment is at the heart of this. We could look at this and say: 'Look at us. Look at the measure of man. Aren't we fantastic?' No other organism does this. But the consequence of this is that we've become so successful at modifying our environment that we've begun to warm the planet in a highly destructive fashion.

**OTHER PARTS OF THE WORLD HOLD DIFFERENT, MORE COMMUNITY-SPIRITED VALUES, AND WE AS A SPECIES HAVE INVENTED THINGS LIKE CHARITY AND SOCIETY WHERE WE DEPEND ON EACH OTHER. DO YOU THINK THIS IS A SIGN THAT WE CAN DO BETTER?**

Those are certainly admirable features of human behaviour. However, even in that case, I find the concentration on humanity, rather than other species, dispiriting. Our treatment of non-human animals, through industrial agriculture, through entertainment, through vivisection within the biological sciences – the justification for so much of this comes down to the importance of humanity. So, I think even in a community setting, we're still concentrating on ourselves, so we haven't escaped from this basic self-adoration.

In terms of whether more communal living and so forth represents a plan for saving the planet, there are certainly some possibilities there. But, at this point, we're approaching seven and a half billion human beings. I think these are like funeral decorations, really.

**SO, DO YOU THINK THAT JUST AS OUR NARCISSISM WAS A PRODUCT OF OUR SUCCESS, THAT IT ALSO PLAYED A PART IN OUR CONTINUED SUCCESS?**

Absolutely. The idea that we're the king of the jungle was a huge part of our success.

But it depends what you mean by 'success'. What is biological success? Is an earthworm less successful than a human being? They'll probably be here a long time after we're gone, so maybe they get two thumbs up.

The International Union for Conservation places humans as in the least vulnerable category right now, because it says that we've populated the whole planet and there are no obvious threats to our continued existence. It seems remarkably naïve.

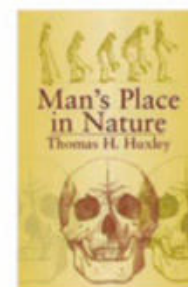
**WOULD YOU SAY OUR EXTINCTION AS A SPECIES IS INEVITABLE?**

Yes. Extinction of every species is inevitable. For us, I think it's something that's coming a lot sooner than many of us would like. Oh yes, the four horsemen of the apocalypse, if I listen, I can hear their hooves clattering outside.

**PROF NICHOLAS MONEY**

Nicholas is professor of biology at Miami University in Oxford, Ohio. His book, *The Selfish Ape* (£14.99, Reaktion Books), is out now. **Interviewed by BBC Science Focus online assistant Sara Rigby.**

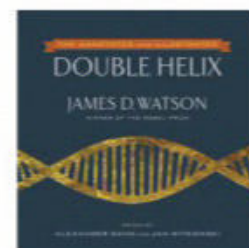
## Author's bookshelf



**MAN'S PLACE IN NATURE**

THOMAS HENRY HUXLEY  
(WILLIAMS & NORGATE)

Among the most provocative books ever published, Huxley's 1863 masterpiece explained that humans are primates and that we are close relatives of chimps and gorillas.



**THE ANNOTATED AND ILLUSTRATED DOUBLE HELIX**

JAMES D WATSON, ALEXANDER GANN AND JAN WITKOWSKI  
(SIMON & SCHUSTER)

Despite Watson's controversial views on many topics, the story of his epiphany in 1953, when he understood how the DNA molecule must be assembled, is inspirational.



**BETTER NEVER TO HAVE BEEN**

DAVID BENATAR (OXFORD UNIVERSITY PRESS)

David develops the most unsettling idea in modern philosophy, that the human experience of existence is best avoided. Sadly, his argument is watertight.



# Deep dive

THIS PICK OF GADGETS SHOULD HELP YOU GET STARTED ON YOUR UNDERWATER ADVENTURE



## CANON 7D MARK II

A universally loved pro-level camera (top and above), the Canon 7D Mark II is a fantastic underwater companion, with a 20.2-megapixel sensor that ensures you won't lose an ounce of detail. It offers sharp autofocus and Canon's proprietary AF tech, which constantly tracks moving objects to keep them defined. It can shoot bursts of images at up to 10fps – handy when there's a school of fast-swimming fish.

£1,429.99 (BODY ONLY), [CANON.CO.UK](http://CANON.CO.UK)



## CANON POWERSHOT G7X MARK II

Once upon a time, camera companies used to make specialist underwater cameras for divers to use. Now, it's just a standard land camera you'll need, with a special housing to keep it dry. The Canon G7X Mark II is a great compact option to start with, which doesn't require the outlay of extra lenses to keep things nice and simple. It offers 20MP resolution with a bright f/1.8-2.8 lens.

£529.99, [CANON.CO.UK](http://CANON.CO.UK)



## CANON WP-DC55 WATERPROOF CASING

So here's the bit that will turn your regular camera into a waterproof one. There are generally two types of housing – this type, which is acrylic and a lot cheaper, or the aluminium versions which are sturdier but more expensive. You might find that you aren't able to use all the buttons and features on the camera through this housing, but the important things will all be accessible.

£279.99, [CANON.CO.UK](http://CANON.CO.UK)



## GOPRO HERO7 BLACK

If you're new to underwater photography, starting out with an action camera like this GoPro is a good first step. As the company's most advanced camera yet, it is waterproof to 10 metres, with 12MP stills and 4K video at 60fps, plus image stabilisation for gimbal-like steadiness. Consider adding a red light filter for replacing the light lost in shallower depths, so your colours pop as they should do.

£379.99, [SHOP.GOPRO.COM](http://SHOP.GOPRO.COM)



## INON Z-330

A strobe light – the name for an underwater flash – is essential for capturing anything beyond a depth of around nine metres. You can use a torch instead, but a strobe will give better results. This one can be used on a compact camera but will futureproof you, should you decide to upgrade to DSLR at any point. Start with one, but be aware most underwater photographers move up to two eventually.

£649.99, [SHOP.INONUK.COM](http://SHOP.INONUK.COM)



## Troubleshoot

# UNDERWATER PHOTOGRAPHY



**IF YOU GET A CHANCE TO GO ON HOLIDAY THIS SUMMER, YOU MIGHT BE TEMPTED TO TRY SOME UNDERWATER PHOTOGRAPHY. AN ACTION CAM AND A SENSE OF ADVENTURE IS ALL YOU NEED, SAYS SAEED RASHEED, EDITORIAL CONSULTANT FOR DIVER MAGAZINE**

### WHAT IS IT ABOUT UNDERWATER PHOTOGRAPHY THAT MAKES IT SPECIAL?

Every time you jump into the water, you don't know what you're going to see, and that makes every single dive really exciting. With land photography, you'll likely set out with an idea of what you want to capture and the kit you'll need, and 9 times out of 10 you'll get it. When you dive, you don't have that guarantee. You have to try and prepare for every situation and take each dive as it comes. But there is just something so special about being underwater and seeing what so few people get to see. Being able to capture those things in pictures and share them with others – there is no other feeling like it.

### WHAT ARE THE BIGGEST CHALLENGES?

We don't have the luxury of tripods like land

photographers do, so when capturing macro shots that require a steady hand, you're often just using one finger to stabilise yourself on a bit of rock, and that's it. We also don't have long down there – the average time is an hour per dive. If the weather and visibility are good, we might be able to get down four times in a day, but conditions can change quickly so it's never a given. Plus there's the difficulty of light. We work with the Sun as much as possible, but as you get deeper you need strobes to lighten up your subject. It's like taking a mini photo studio down with you!

### HOW HAS YOUR KIT BAG CHANGED OVER THE YEARS?

My very first underwater camera was a really cheap one I bought in duty free on my way to Australia in the late 1990s. It could take 36 pictures at a time on film, and you would go through rolls and rolls of film just to get a few shots you liked. Now, I shoot on a Canon 7D Mark II and generally use one of three lenses – a Tokina 10-17mm fisheye lens for wide angle, and either a Canon 60mm or a Sigma 105mm for macro shots. On top of that, you need the waterproof housing – mine is from Nauticam – and strobes for lighting. It's not cheap. A top end system can cost the best part of £10,000, but even a decent entry level setup is going to cost you upwards of £2,000.

### SO HOW CAN PEOPLE GET STARTED?

It depends how seriously you want to take it. An action cam is a good place to start, and you can get pretty decent shots for hundreds of pounds, rather than thousands. Then, if you get the bug, you can start building a compact camera setup from there – I always recommend people buy second hand to start with as you'll always find someone upgrading their kit and selling their old setup at a decent discount.

### DO YOU NEED TO BE HANDY WITH PHOTOSHOP?

Absolutely. Like with all photography, you

✕ **“We don't have tripods – you're often just using one finger to stabilise yourself on a bit of rock”**

can get it right in camera but it's less likely, and much more difficult when you're in the water. Even on the best day for visibility, it can still look like there's a snowstorm in your shot. Being able to remove all that sediment – or what we call backscatter – in an edit is essential to getting the most from your shot, as is being able to replace some of the colours you've lost with lack of light.

### WHERE IS BEST FOR UNDERWATER PHOTOGRAPHY?

You don't have to travel. Seals and blue sharks are among my favourite things to photograph, and you can find them both in waters around the UK. Just five hours away, Egypt is a diver's playground and further afield, the reefs of Indonesia are breathtaking. But for all the beauty we have, I am also really aware of what we are losing. I feel I have a duty as an underwater photographer to share as many pictures as possible, of the good and the bad, so people know how amazing it is down there, but also see what we are doing to it, too.

— **SAEED RASHID** (@saeedrashid)

Saeed is a member of British Society of Underwater Photographers and is editorial consultant for Diver magazine. He holds workshops and talks on underwater photography via his company, Focus Visuals.



# RECOMMENDED

FIND OUT WHAT'S CAUGHT OUR ATTENTION THIS MONTH



## WHAT I'M TESTING

**Alice Lipscombe-Southwell**  
(with the help of a new mum)  
PRODUCTION EDITOR



### ELVIE BREAST PUMP

£249, [ELVIE.COM](http://ELVIE.COM)

Breastfeeding is hard: fact! So anything that gives a mother a break from the relentlessness is a winner. My friend, Lae, has tried standard pumps, but being strapped to a noisy machine with wires and tubes is not what she would call a break. That's where this pump comes into its own, and she found it to be a gamechanger (if you want to call it a game).

The Elvie pump is small, and fits neatly inside a nursing mother's bra, where it gently expresses milk via seven different intensity settings. Lae washed up, drove, and even enjoyed her dad's 70th birthday party while discreetly using the pump. She loves that it has given her a little bit of freedom and taken the edge off her breastfeeding journey.

While it's possible to pump without using the accompanying app, the app allows you to control the pump from your phone, and track things like milk volume over time. The battery charges quickly via micro-USB and holds its charge well. The only thing she found was that it is better to stay upright while you are using it. Although you can wander around, the stiller you are the greater the yield.

It's a brilliant piece of tech, designed to help mothers through what can be a tough time.



## WHAT I'M READING

**James Lloyd**  
STAFF WRITER



### FRANKISSSTEIN

BY JEANETTE WINTERSON  
(£16.99, JONATHAN CAPE)

Jeanette Winterson's latest book is a shape-shifting, time-hopping gem of a novel that takes the latest thinking around artificial intelligence (AI) and weaves it into a compelling love story involving sexbots, cryonics, and 19th Century romanticism.

*Frankissstein* is inspired by Mary Shelley's classic 1818 novel, and whisks us back in time to the now-famous holiday on the banks of Lake Geneva, where Shelley first conceived of the artificial life form that would make her famous. Meanwhile, in the present day, we follow the story of a young doctor called Ry, who is falling in love with Victor Stein, an expert in all things AI.

Reading one of Winterson's books is like going on a magic carpet ride through her subconscious. Best known for her debut 1985 novel *Oranges Are Not The Only Fruit*, her stories are creative, overflowing with ideas, and shot through with her wicked sense of humour. The most memorable character in *Frankissstein* is Ron Lord, a divorced man who's masterminding a new generation of sex dolls. He's brash, bawdy and un-PC, but also emblematic of the questions that run through this book: how is technology changing the way we love? And at what point can the artificial become human?



## WHAT I'M TESTING

**Daniel Bennett**  
EDITOR



### JABRA ELITE 85H

£279, [JABRA.CO.UK](http://JABRA.CO.UK)

I don't like earphones. They tire my ears out after a while, so over-ear headphones tend to be easier on my hearing. In the confines of my flat, this means I listen to music via a pair of hi-fi quality headphones with an open-back, that lets some of the noise and air pressure escape. They're also lightweight and the earcups are lined with a breathable material which makes them comfortable to wear for a whole evening. This isn't a humble brag; my point is I'm yet to find a pair of wireless headphones that come close in terms of comfort, let alone sound.

That's the first thing that's stood out about this new pair of Jabras. At 275g, they don't seem particularly light, and the cans come lined in faux leather which usually isn't a great combo for comfort. And yet the ergonomic design, and perhaps how the weight is spread out through the frame, make for a supremely comfortable pair of headphones for your commute, which is exactly what they were designed for. The Elite 85h is built with Jabra's 'Digital Hybrid Active Noise Cancellation', which is their way of saying the headphones can listen to the world around you and filter out the noises you don't want, like the rattle of a train, while allowing through the noises you do





need to hear, like fast-approaching cars. It's also supposed to be just as useful if you're at home and want some peace and quiet, but don't want to your other half to throw pens at you to get your attention.

I tried out SmartSound on our commute. The software on the Jabra Sound + app listened in and realised I was stood in public and stifled the droning buses stuck in traffic, while leaving the screeches and squeaks made by its brakes intact. The idea is that it's supposed to tune in every few minutes and see if the headphones need to let in more or less sound. In practice, this meant occasionally you're surprised by a particularly loud car or conversation. But that's no bad thing if it means you're a little more aware of your surroundings.

For the most part the sound pumped out by the Jabras is brilliant.

They stand up well to most lauded headphones in this price range from the likes of Sony and Bose. The treble is crisp and clean, and the overall sound feels roomy and inviting. Experimental rock band Yeasayer's ambling keyboards and delicate riffs sing through. But put on something that demands a little more bass like Thom Yorke's new LP *Anima* and the bass notes are a little lacking.

Audiophiles might be put off by the absence of some high-end audio codecs, which support lossless audio quality over Bluetooth. If, like me, you get your music mostly via Apple Music or Spotify you won't notice the difference and it could be addressed via an update in the future.

The full-on noise cancellation is excellent. They made my bus ride almost serene, were it not for the sweltering heat. And they avoid the 'I've suddenly been sucked into an

empty void' sensation that we felt with other noise-cancellation tech. The headphone's battery life, at 36 hours with noise-cancelling turned on, is top of its class and will mean you can use them all week before you have to plug them into a charger.

At £279, they're not cheap, but the Elite 85h does offer features and audio quality of headphones that are usually over the £300 mark. There's the aforementioned Jabra Sound + app, which gives you an equaliser (so you can turn the bass up), different noise-cancelling settings and even some 'Soundscapes'. The headphones automatically turn on and connect to your phone or computer when they're unfolded, and house some buttons on the cans to let you flick through your preset settings. All in all, they don't scrimp on quality or features, and are affordable in this price range.

The Elvie breast pump keeps both hands free, so nursing mothers can get on with their day while expressing milk



# DISCOVER MORE

SQUEEZE EXTRA JUICE OUT OF THE TOPICS IN THIS ISSUE OF *BBC SCIENCE FOCUS* WITH THESE BOOKS, WEBSITES AND SHOWS

## Eye opener p6

### AI-DA DRAWING

Watch Ai-Da the robotic artist at work as she draws a portrait using her mechanical arm. She's able to draw people from sight, using AI algorithms to convert what she sees into an abstract style that's inspired by Expressionism and Cubism.

[bit.ly/ai\\_art](http://bit.ly/ai_art)

## Reality check p28

### THE DANGERS OF PLASTIC IN OUR OCEANS

Dr Lucy Quinn from the British Antarctic Survey looks at the plastic ingested by an albatross in this clip from *Blue Planet II*.

[bit.ly/plastic\\_albatross](http://bit.ly/plastic_albatross)

### IS THERE SUCH A THING AS A SAFE TAN?

Michael Mosley asks dermatologists Dr Richard Weller and Prof Charlotte Proby how much Sun exposure is too much.

[bit.ly/safe\\_tan](http://bit.ly/safe_tan)

## Practising for the Moon p36

### LUNAR LANDING RESEARCH VEHICLE TEST FLIGHT

In this vintage NASA clip, Neil Armstrong carries out a training flight of the Lunar Landing Research Vehicle (LLRV) shortly before heading to the Moon. This basic aircraft was designed to simulate the feel of a vertical take-off and landing in low gravity.

[bit.ly/apollo\\_training](http://bit.ly/apollo_training)

## Space exploration: the next 50 years p44

### 8 DAYS: TO THE MOON & BACK

BBC TWO, CHECK [RADIOTIMES.COM](http://RADIOTIMES.COM) FOR DETAILS

This feature-length drama documentary takes viewers into the heart of the Apollo 11 mission to the Moon, using declassified cockpit audio and digital trickery to bring the monumental journey to life.

### STARGAZING: MOON LANDING SPECIAL

BBC TWO, CHECK [RADIOTIMES.COM](http://RADIOTIMES.COM) FOR DETAILS

Prof Brian Cox and Dara O Briain travel to Cape Canaveral in Florida. They hear first-hand from astronaut General Charlie Duke what it was like to guide Neil Armstrong and Buzz Aldrin to the surface of the Moon.

## James Lovelock interview p56

### GAIA: A NEW LOOK AT LIFE ON EARTH

BY JAMES LOVELOCK  
(£8.99, OXFORD UNIVERSITY PRESS)

In this seminal work, Lovelock puts forward the idea that he's best known for today – that the Earth functions as a single, self-regulating organism. Written for non-scientists, Lovelock explains Gaia theory with characteristic simplicity and clarity.

## How to argue with a Moon landing denier p64

### MOON BASE CLAVIUS

This organisation of amateur and professional space enthusiasts was set up to debunk the conspiracy theory that the Moon landings were hoaxes. Their site contains analysis of photos and comprehensive responses to all of the conspiracy theorists' main arguments.

[clavius.org](http://clavius.org)

### SUSPICIOUS MINDS: WHY WE BELIEVE CONSPIRACY THEORIES

BY ROB BROTHERTON  
(£9.99, BLOOMSBURY SIGMA)

For a broader look at how conspiracy theories come about in the first place, this fascinating book by psychologist Dr Rob Brotherton is a good place to start. He explores the long history of conspiracy theories, and delves into the reasons why so many of us are drawn to ideas that make little logical sense.

## A scientist's guide to life p98

### WHY BOREDOM IS GOOD FOR YOU

This short film by BBC Reel, narrated by psychologist Dr Sandi Mann, explains some of the surprising benefits of boredom.

[bit.ly/boredom\\_good](http://bit.ly/boredom_good)

### HOW BOREDOM CAN LEAD TO YOUR MOST BRILLIANT IDEAS

Always have your best ideas while standing in the shower? In this TED talk, journalist, author and podcaster Manoush Zomorodi explores the connection between spacing out and creativity. She also wrote *Bored And Brilliant*.

[bit.ly/bored\\_brilliant](http://bit.ly/bored_brilliant)

FOR MORE, FOLLOW US

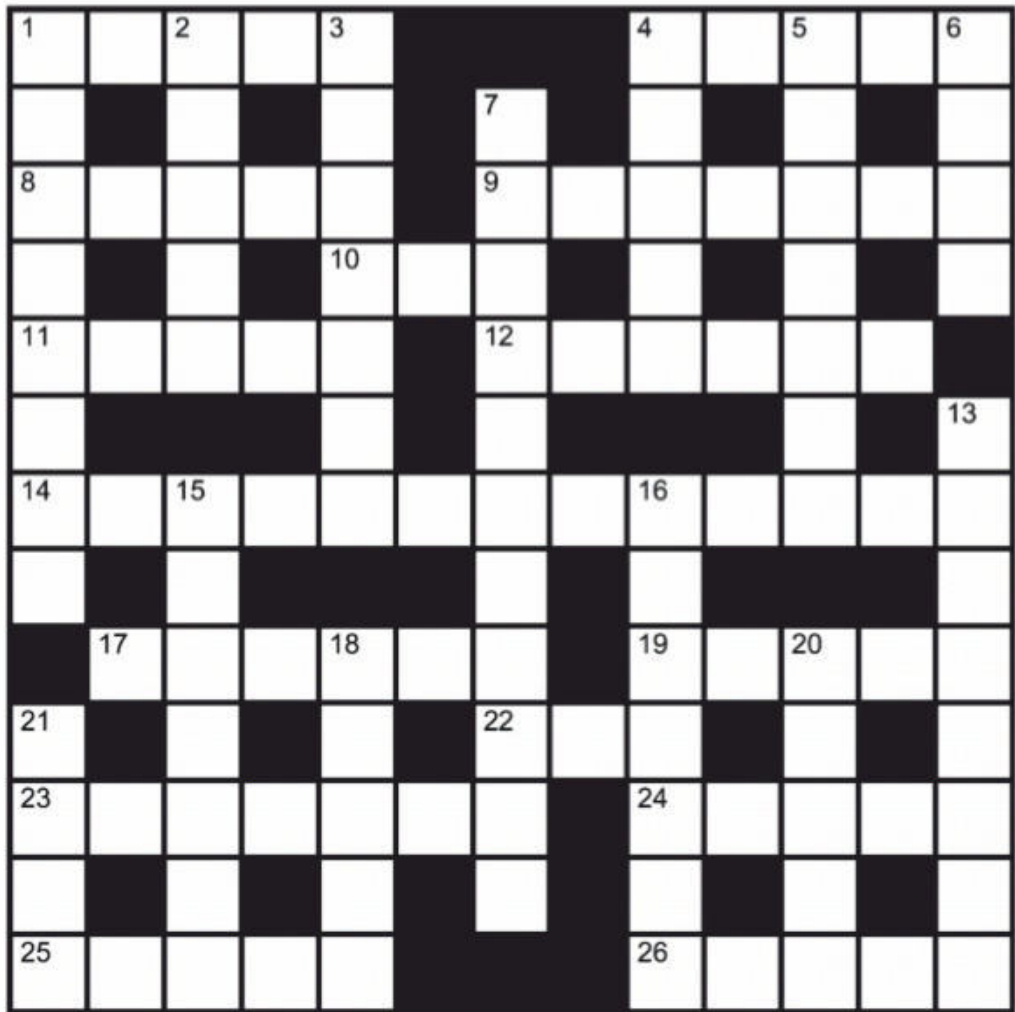


@SCIENCEFOCUS



# CROSSWORD

## GIVE YOUR BRAIN A WORKOUT



### ACROSS

- 1 Attracted to get registered in the morning (5)
- 4 Reported location for one of the senses (5)
- 8 Sign fluctuates without starting (5)
- 9 Almost like a horse and a bull for a day in March (7)
- 10 Element from continent's heart (3)
- 11 Animal less cold in the East End (5)
- 12 Ship wasted energy in some water (6)
- 14 Claimed my sets used were in base ten (7,6)
- 17 Aim: move around – rule country (6)
- 19 Thing got broken in darkness (5)
- 22 Choke on a joke (3)
- 23 Crib transformed with time into vital frame (3,4)
- 24 Cat flap nearby (5)
- 25 Courage to get a transmitter (5)
- 26 It happened in the Seventies (5)

### DOWN

- 1 Maid nods about suit (8)
- 2 Advertisers initially lean on top celebrities (1-4)
- 3 Negative way with strange patent medicine (7)
- 4 Ability, swapping one with universal bone (5)
- 5 Libertine captures a French and British naval ship (7)
- 6 Cricket team volunteers first to get transport (4)
- 7 Boy and girl row about girl's first cat (6,5)
- 13 Teams played with your old stone (8)
- 15 Cleaner accepts award, showing a bit of heart (7)
- 16 Get any excursion around unknown river (7)
- 18 Agricultural leader donated a tropical plant (5)
- 20 Part of wall bolstered top in storm (5)
- 21 Bishop managed to get some roughage (4)

GETTY IMAGES

### ANSWERS

For the answers, visit [bit.ly/BBCFocusCW](http://bit.ly/BBCFocusCW)  
Please be aware the website address is case-sensitive.

## NEXT ISSUE

# COVER STORY

## WHAT DINOSAURS CAN TELL US ABOUT OUR FUTURE

Research into past mass extinctions is providing new insights into the environmental challenges we face today



## PLUS

### ANIMAL SHOW-OFFS

Shake your tail feathers and find out about some of Earth's most flamboyant creatures.

### ELECTROCEUTICALS

We speak to Gordon Wallace, the scientist who wants to replace pills with implantable electricals wired straight into your nervous system.

# ON SALE 7 AUG





## A SCIENTIST'S GUIDE TO LIFE

# BORED GAMES

AS THE SUMMER HOLIDAYS UNFOLD AND HOMES EVERYWHERE RESOUND TO THE SOUND OF, "MUM, I'M BORED!" PSYCHOLOGIST **SANDI MANN** REVEALS WHY IT'S SOMETIMES GOOD TO BE BORED



### WHAT IS BOREDOM?

It's a search for neural stimulation. When that search is not satisfied, we call it boredom.

### DO WE GET BORED MORE EASILY THAN PREVIOUS GENERATIONS?

I think so. With smartphones, we have the whole world at our fingertips. We're always swiping and scrolling and searching for novelty. It gives us a hit of the 'feel-good' chemical, dopamine, which is addictive, so we're always left wanting more. The more stimulation we have, the more we need. This means we get bored more easily.

### I EAT WHEN I'M BORED. SHOULD I HIDE THE CHOCOLATE?

Yes. Our research has shown that eating chocolate is one of the most common things we do when we're bored. We gave bored people a choice of snacks, and found that they rarely chose the healthy option. It's because you get more of a dopamine hit from fatty foods. It could be worse though. Some people have committed murder out of boredom.

### CAN YOU BE BORED TO DEATH?

There's some substance to this. Research shows that people with boring jobs, like civil servants, have a lower life expectancy. We suspect it's because

when you're bored, you're more likely to eat unhealthy foods, drink alcohol and take part in risky behaviours like speeding or unsafe sex. These sorts of things lead to an earlier death.

### HOW CAN WE STOP BEING BORED?

The paradox is that we need to introduce more boredom into our lives in order to become less bored. I'm passionate about having a digital detox. Swim. Go for a walk without music. If you're on a train, look out of the window. When I commute to work, I don't have the radio on. I let my mind wander. When get in my head is often brimming with ideas.

### SHOULD WE EMBRACE BOREDOM?

Yes. I'm a strong believer in being properly bored every day. We did a study where we got people really bored by asking them to copy numbers from a telephone directory. Then we gave them tests of creative potential, like thinking up new uses for plastic cups. The bored group were more creative than controls who didn't do the boring task, so boredom can make us more creative.

### WHAT'S THE BEST WAY TO KEEP KIDS ENTERTAINED?

Parents are under so much pressure to be perfect. If we're not educating and stimulating our children, then we feel we're failing. I want to take that guilt away and say it's okay to let your children make their own entertainment.

Avoid giving them too much choice. We did some research for an airline company, who wanted to find ways to keep kids entertained on long flights. We found that when you give kids a whole bag of toys, they pick up each thing, play with it for a few seconds, then put it down. But if you give them one thing at a time, they spend much longer with it. Also, when we gave them something 'boring' like a notepad and pen, and nothing else, they were amazing! They wrote and drew stories and kept themselves busy for ages. Sometimes the best toys can be simple. **SF**

### NEED TO KNOW...

# 1

On your commute, turn off the music and let your mind wander.

# 2

Hide the chocolate and crisps if you're going to be working on a boring project.

# 3

If your kids moan that they're bored, tell them to entertain themselves.

### DR SANDI MANN

Sandi is a psychologist from the University of Central Lancashire. She is the author of *The Science Of Boredom: The Upside (And Downside) Of Downtime* (£9.99, Robinson).

Interviewed by  
**Dr Helen Pilcher.**





# Thank you, Sylvia

## Sylvia left a gift in her Will to help conquer Stroke

The first we knew of Sylvia was when we received notification of the gift she'd left us in her Will. Shortly after, a beautiful story of a much-loved woman began to unfurl.

Friends remembered Sylvia's kind-heart and her wish to help others. She spent part of her adult-life caring for her mother, and developed a passion

for medicine. Becoming a medical secretary was her next step and, in the course of her career, she discovered the devastating impact a stroke could have on people and their families. She saw that research and treatment were vastly under-funded, and she decided to remember the Stroke Association in her Will.

Sylvia's gift has helped fund our work to conquer stroke. She's supported research to prevent and treat stroke, and she's helped care for survivors. And that's something you can do too – in the same way.

**If you would like to learn more about remembering the Stroke Association in your Will, please get in touch.**

**Call 020 75661505 email [legacy@stroke.org.uk](mailto:legacy@stroke.org.uk)  
or visit [stroke.org.uk/legacy](https://stroke.org.uk/legacy)**

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**Stroke**  
association



# LIONS OF LYON

THIS CAPTIVE PRIDE NEEDS YOUR HELP

Four lion cubs just a few weeks old were recently rescued from appalling captive conditions and saved from life as pets. Kept in a car, a garage and an apartment, these lions deserve a better future. You can help give them a lifetime home in Africa.

ILLEGALLY KEPT AS PETS

SEPARATED FROM THEIR FAMILIES

DEPRIVED OF A LIFE IN THE WILD

**URGENT**

The four cubs are currently being cared for in Lyon, France. **With your help, we can give them a life free from harm at our big cat sanctuary in South Africa.**

**SAVE THESE LIONS TODAY**  
[www.bornfree.org.uk/lions-of-lyon](http://www.bornfree.org.uk/lions-of-lyon)

Image © www.georgelogan.co.uk



Charity No:1070906

\*By texting, you are agreeing for Born Free to phone or text you to tell you about our work and how you can help. You will be charged £10, plus your standard network rate. 100% of your donation will go to Born Free. If you wish to donate and not hear from us again, text LIONS NO to 70577. For more information call 01403 240170. The Born Free Foundation is a registered charity 1070906